

# Using crime science for understanding and preventing theft of metal from the British railway network

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Thesis submitted in partial fulfilment of the requirements for the degree  
of PhD in Crime Science (UCL) of the University of London in 2016

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## STUDENT'S DECLARATION

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I, Matthew Ashby, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Matthew Ashby

August 2016





## ABSTRACT

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Metal theft has emerged as a substantial crime problem, causing widespread disruption and damage in addition to the loss of metal itself, but has been the subject of little research. This thesis uses the paradigm of crime science to analyse the problem, focusing on thefts from the railway network in Great Britain.

Two theoretical concepts are used: crime scripts and the routine-activities approach. Police-recorded crime and intelligence data are used to develop a crime script, which in turn is used to identify features of the problem a) analysis of which would potentially be useful to practitioners seeking to understand and prevent metal theft, and b) for which sufficient data are available to make analysis practical. Three such features are then analysed in more detail.

First, spatial and temporal distributions of metal theft are analysed. Metal theft appears to differ from other types of acquisitive crime in ways potentially useful for prevention, for example in clustering outside (but close to) cities, and in exhibiting significant repeat victimisation over a longer period than found for other crimes.

Second, the potential crime-prevention value of the market-reduction approach is analysed by testing for clusters of thefts close to the locations of scrap-metal dealers. Scrap-yard locations are found to be a significant predictor of local thefts, controlling for metal availability, area accessibility, and density of population and industry.

Third, the involvement of organised crime groups (OCGs) in metal theft is tested. Due to the difficulty of defining and measuring organised crime, multiple approaches are used: all show OCG involvement to be rarer than official estimates previously suggested.

The implications of these findings for practitioners are discussed. The thesis also considers the relevance of the results for the use of crime science and the analysis of OCGs.

This thesis is 62,698 words long.



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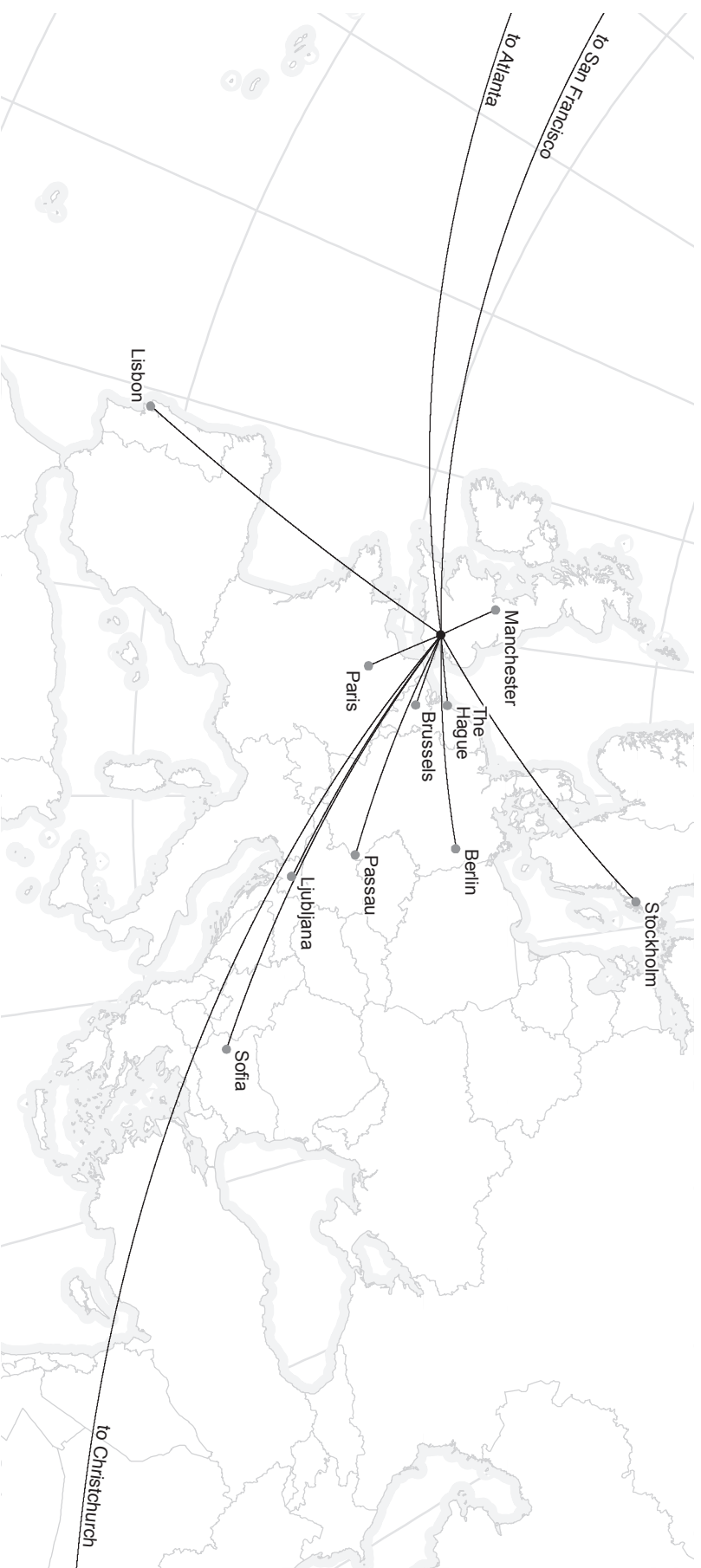
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*Trips made for the completion of this thesis*



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## PUBLICATIONS

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Some of the material presented here has previously appeared in the following publications:

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Material from this thesis was also presented at the following conferences:

- American Society of Criminology annual meeting, Atlanta, November 2013.
- Pol-PRIMETT II annual conference, London, February 2014\*
- Streets, Crime and Transport seminar, London, February 2014†
- Pol-PRIMETT II annual conference, Lisbon, October 2014\*
- American Society of Criminology annual meeting, San Francisco, November 2014.
- International Union of Railways (UIC) expert panels, Paris, December 2014 and February 2015†
- International Crime and Policing Conference, London, February 2015\*
- Exploring New Ways to Tackle Metal Theft meeting, London, February 2015†

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\* This conference was attended mainly by crime-prevention policy makers.

† This conference was attended mainly by crime-prevention practitioners.

- Pol-PRIMETT II meeting in Sofia, March 2015.<sup>†</sup>
- Environmental Criminology and Crime Analysis symposium, Christchurch, June 2015
- Pol-PRIMETT II meeting in Berlin, July 2015.\*
- International Crime and Intelligence Analysis conference, Manchester, February 2016.<sup>†</sup>



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## ABBREVIATIONS

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ACPO	Association of Chief Police Officers
BPM	business process modelling
BTP	British Transport Police
CCTV	closed-circuit television
CHI	crime harm index
CRAVED	concealable, removable, available, valuable, enjoyable and disposable
CSR	complete spatial randomness
EA	Environment Agency
EIM	Association of European Rail Infrastructure Managers
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
GPS	global positioning system
IDEF0	Integration Definition for Functional Modeling
JISC	Joint Information Systems Committee
km	kilometre
LISA	local indicators of spatial association
LOESS	locally weighted scatterplot smoothing
LULU	“locally undesirable land use”
MAUP	modifiable areal unit problem
MRA	market reduction approach
NB	negative binomial
NCA	National Crime Agency
NICB	National Insurance Crime Bureau
NNI	nearest neighbour index
OCG	organised crime group
OLS	ordinary least-squares
PCP	phencyclidine
PNC	Police National Computer
SCP	situational crime prevention

SECRiT	Security Science Doctoral Research Training Centre
SMD	scrap-metal dealer
sq km	square kilometre
UCL	University College London
UIC	International Union of Railways
UK	United Kingdom
UN	United Nations
UNCTOC	United Nations Convention against Transnational Organized Crime
US	United States
VIVA	value, inertia, visibility and access





## INTRODUCTION

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This thesis applies the emerging discipline of crime science to the recently emerged crime problem of metal theft, with a focus on the railway network in Great Britain<sup>1</sup>.

In the past decade there has been a large increase in the problem of metal being stolen for its resale value (Home Office, 2013), likely driven by the increasing wholesale price of many scrap metals (Sidebottom et al., 2011, 2014). As a result, metal theft has become a crime problem receiving substantial attention among academics, policy makers and practitioners (see Chapter 3). This attention has been driven particularly by the high level of damage and disruption that metal theft can cause. The cost of replacing stolen metal and the damage caused by its theft is often grossly disproportionate to the value of the items stolen (Brathwaite et al., 2013; Price et al., 2014). In particular, when metal is stolen from power networks or railway lines, the theft has the potential to cause disruption to many thousands of people. This has led to pressure on governments in many countries to take action to prevent metal thefts from occurring.

This attention has so-far resulted in a relatively small pool of published information on the nature of metal theft and how to prevent it. What literature exists is reviewed in Chapter 4. The present thesis therefore attempts to fill some of the many research gaps that exist.

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<sup>1</sup> As will be explained in Chapter 5, the data used for the empirical chapters that follow were obtained from British Transport Police. That force is the specialist police service for the railway network of the United Kingdom with the exception of Northern Ireland, and so analysis based on their data is limited to Great Britain.

### 1.1 DEFINITION OF METAL THEFT

Metal theft is defined by Home Office (2013) as “thefts of items for the value of their constituent metals, rather than the acquisition of the item”. This definition will be applied in this thesis because it has been adopted by practitioners and matches the terms in which metal theft is understood and discussed by them. As such, using this definition helps to ensure that the present research is useful to those attempting to prevent or detect metal thefts (see Section 2.2).

This definition of metal theft is based on the intention of the thief in any particular case. So, for example, the theft of a brass plaque from a war memorial would be a metal theft if the thief intended to sell the metal for scrap, but not if he or she intended to sell it to a collector of historical artefacts. The need to infer offender motivation in a situation where the offender will often not be caught introduces a potential problem into the definition. However, it will commonly be unproblematic to infer the thief’s intention. For example, a thief who cuts up lead sheets from a church roof and takes them away can be inferred to be doing so for the scrap value of the metal rather than for any other purpose. Conversely, a thief who steals an artistically valuable bronze sculpture during the burglary of a manor house could be stealing it for its resale value as art rather than as scrap metal. In the case of railway metal theft, however, it is unlikely that the offender’s motives will often be in doubt since the items stolen (such as copper signalling cable) have almost no resale value other than as scrap.

### 1.2 THE STRUCTURE OF THIS THESIS

The research presented here was designed to produce knowledge that would be useful either to academics or practitioners in understanding and preventing metal theft (see Sections 2.2 and 6.5). As will be discussed further in Section 10.1, this emphasis on practical application has produced a thesis that does not follow a conventional format. Instead, the structure of this thesis is determined by the nature of the research conducted, using mixed methods to answer multiple research questions. Common issues are discussed first (in Chapters 2 to 5) before the consideration of each question in turn (in Chapters 7 to 9). Table 1.1 summarises the research questions with the data and methods used to answer them. Chapter 6 bridges these two parts of the

thesis by using a crime script to identify which potential avenues of research on metal theft are most likely to be both useful to practitioners and capable of being addressed using currently available data and methods.

Chapter 2 outlines the theoretical framework that underpins this thesis. First the discipline of crime science is introduced along with various critiques that have been made of it. The concept of 'good enough' theory, which is used to evaluate much of what follows, is introduced next. The meta-theoretical rational-choice perspective to understanding crime is then described, before two theoretical perspectives based on it are introduced. The first is the idea of the crime script, which is used (in Chapter 6) to identify and analyse the steps that make up the process of committing a crime. The second is the routine-activities approach, which is used (in Chapter 3 and elsewhere) to understand the actors involved in metal theft.

Chapter 3 explains the problem of metal theft in more detail. Explanations for why metal theft has recently arisen a distinct crime problem are discussed, including why metal is a vulnerable target for theft. Different types of metal theft are distinguished to allow a subsequent focus on thefts from the railway network. The particular vulnerability of metals used on railways is discussed, as is the vulnerability of the network to the impact of metal theft.

Chapter 4 reviews the existing literature on metal theft. Given the limited number of publications in this area, a broad approach is taken including the use of government and third-sector reports and other documents. Gaps in the literature that it may be useful to fill are identified (in Chapter 6) to assess the potential value of the empirical work presented in later chapters.

Chapter 5 describes the data used in this thesis, identifies their limitations and discusses why they are likely to be both a) 'good enough' and b) the best available at the present time. Two sources of data are introduced: one detailing metal *thefts* and one providing information on metal *thieves*. Sample sizes and other contextual information are given to allow the reader to interpret the results presented afterward. For ease of reading, subsidiary datasets used in a single part of the empirical analysis are presented later, in the relevant chapter.

Chapter 6 bridges the theoretical and empirical parts of this thesis by outlining a crime script for metal theft from the railway network, using the framework discussed in Chapter 2. The process of stealing railway metal is divided into five units, each of which is composed of multiple functions that must be completed in order for an offender to successfully profit from

Table 1.1: *Summary of research questions answered in the empirical chapters of this thesis, with the data and methods applied to each.*

Research question	Data	Methods
<i>Chapter 6:</i> What are the events that make up the process of metal theft from the railway network, and which of these events may be usefully studied?	Narrative descriptions of the methods used in 400 metal thefts, obtained from the PNC (see Section 5.3).	Content analysis using grounded, descriptive coding to identify recurrent features of metal theft, combined with information obtained from informal discussion with expert practitioners (see Section 6.2).
<i>Chapter 7:</i> How does metal theft from railway networks concentrate in space and time, and how does this vary from patterns previously seen in other types of crime?	Police-recorded crime data for metal thefts from the railway network (see Section 5.2).	Statistical tests appropriate for data with spatial and temporal autocorrelation (see Sections 7.4 to 7.7).
<i>Chapter 8:</i> Is metal from railway networks more likely to be stolen in areas with more SMDs?	Police-recorded metal-theft data combined with demographic information and the locations of SMDs (see Section 8.6).	Negative binomial regression with a spatial-lag variable to account for spatial autocorrelation in the data.
<i>Chapter 9:</i> to what extent are OCGs involved in metal thefts from railway networks?	Narrative descriptions of offence methods and the previous convictions of people arrested for metal theft (see Section 5.3).	Multiple methods to test different features of metal theft that could indicate the involvement of OCGs (see Section 9.3).



stealing metal. The relationships between different units, and the resources and mechanisms on which they depend, are discussed. This information is then used, together with the gaps in the literature identified in Chapter 4, to decide on which issues could usefully be the subject of further enquiry. Three such issues are identified, each of which is the subject of a subsequent chapter.

Chapter 7 analyses the spatial and temporal patterns of metal theft from the railway network in Great Britain. Thefts are found to be significantly spatially clustered, with second-order clustering also apparent. In contrast to many other types of acquisitive crime, metal thefts appear to be clustered on the edges of cities rather than in city centres. Thefts are also found to be temporally clustered, with the greatest clusters occurring at night. A significant elevation of risk of further victimisation at the location of a previous theft is found, consistent with previous work on other types of theft. However, this risk appears to persist for much longer than has previously been found for other acquisitive crimes such as domestic burglary. These differences from other types of crime are discussed in relation to the routine-activities approach introduced in Chapter 2.

Chapter 8 considers the empirical basis for the market reduction approach (MRA) to crime reduction that has been frequently suggested for the prevention of metal theft, particularly in relation to the activities of SMDs. Due to limitations of the available data, which are discussed in this chapter, an indirect approach is taken. This tests whether there are more metal thefts from railway lines that are close to SMDs and finds that there are. The implications for this are discussed, both in relation to the MRA (for which previous empirical evidence has provided only partial support) and for policies aimed at preventing metal theft by regulating SMDs.

Chapter 9 tests the oft-asserted hypothesis that metal theft is committed by OCGs. Since there is no universally accepted definition of an OCG, multiple features that may be associated with such groups are tested in order to ensure that the analysis is robust. The tested features were selected based on previous literature and on discussions held with practitioners. This analysis finds that very few metal thieves have convictions for offences related to OCGs or are linked to such groups by police intelligence information. Metal thieves are also found to typically offend closer to home than OCG offenders reported in the literature and to use unsophisticated methods to steal metal. Overall, the proportion of metal thefts linked to OCGs appears to be at least

an order of magnitude lower than official estimates. The importance of this finding for the organisation of future practice in preventing metal theft is discussed.

The extended discussion in Chapter 10 covers three overarching issues that arise in the previous chapters. The first discusses the applicability of crime science to the problem of metal theft, and the issue of taking action based on provisional or limited research. The second proposes that organised crime be studied as a multi-dimensional space rather than as a one-dimensional continuum or as an undifferentiated whole, and illustrates such a space defined according to variations in the degree of networking, harm and sophistication associated with particular types of crime. Finally, the question of whether recent changes in the nature of metal theft in the United Kingdom (UK) mean that it can be considered as a solved problem is addressed.

This thesis concludes in Chapter 11 with a summary of the findings of previous chapters and the concepts discussed in them, before making suggestions for future research in this area.

As will be discussed in the next chapter, the value of crime science is to produce research that is valuable to practitioners in preventing or detecting crime. In order to facilitate this transfer of knowledge, each chapter begins with a brief summary of its contents written so as to be accessible to practitioners. The author is a former police officer and so is particularly concerned with ensuring that research has practical value.

### 1.3 THE CONTRIBUTION OF THIS THESIS

The research reported in this thesis makes a number of contributions to the study of metal theft, some of which have value for the study of crime in general. These contributions will be discussed in more detail in the chapters that follow, but some examples are given here to demonstrate the value of the work overall.

Firstly, Chapter 6 demonstrates that crime scripting can be used to identify and prioritise research questions for the analysis of new crime types. This is valuable because when new crime problems arise it is likely that practitioners will come under pressure to respond to them quickly, and there will be a consequent need for the rapid production of evidence on which to base such responses (see Section 10.1.1). Using a crime script can allow analysts to identify research questions that are both useful and testable, as discussed

in Section 6.5. The use of Integration Definition for Functional Modeling (IDEF0) conventions more normally used in engineering (see Section 2.5.1) demonstrates the value of the emphasis within crime science of adopting techniques from other academic disciplines (see Section 2.2).

Secondly, the analysis of spatial and temporal patterns of metal theft presented in Chapter 7 shows some differences from the patterns found for other types of crime. For example, the risk of repeat metal thefts appears to persist for several months, rather than a few weeks (see Section 7.6). This finding is valuable for practitioners because it allows police to consider deploying resources to the locations of previous metal thefts for longer than they might have done if the decision were based on previous research findings generated from the study of other crime types. It is also valuable to academics because it illustrates the importance of conducting analysis that is specific to a particular type of crime (see Section 2.4.3).

Thirdly, the finding in Chapter 8 that metal thefts are significantly more common in areas with more SMDs is valuable to practitioners because it provides empirical evidence on the potential value of regulating scrap transactions as a method for preventing metal theft (see Section 8.9). It is valuable in academia because it provides evidence on the validity of the MRA, an idea with intuitive appeal that has hitherto found only limited empirical support (see Section 8.2).

Fourthly, the findings reported in Chapter 9 suggest that OCGs are involved in metal theft substantially less often than has previously been supposed. This finding is valuable to practitioners because it suggests that those seeking to prevent or disrupt metal theft should look beyond techniques normally associated with tackling organised crime in their responses to metal theft (see Section 9.9). For those who research crime, this finding is valuable because it illustrates the importance of testing the assumptions that expert practitioners make about the nature of crime problems.

Fifthly, the analysis in Section 7.8 suggests that metal thieves often plan their offending, at least to a certain extent, even though they are usually not part of an OCG. This illustrates the importance of the emphasis that rational-choice theorists place on studying specific types of crime in detail (see Section 2.4.3), and suggests that existing binary or uni-dimensional definitions of organised crime (for which, see Section 9.2) are inadequate. As such, a new multi-dimensional approach to defining organised crime is presented in Section 10.2.





## THEORETICAL FRAMEWORK

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### SUMMARY

- This thesis takes a crime-science approach to understanding and preventing metal theft.
- Crime science adopts a 'good enough' approach to theory, in which theories are used if they are supported by the available evidence and produce predictions that are useful for preventing crime.
- The theoretical frameworks used in this chapter are based on the rational-choice perspective, in which offenders are seen as making criminal decisions in the way that people in general make everyday decisions. This perspective emphasises the importance of analysis being specific to particular types of crime in particular contexts, since the factors influencing offender decisions are likely to vary for different crimes.
- An individual crime can be conceptualised as a sequence of steps, which can be analysed by constructing a crime script. This process also allows identification of which steps within a criminal process may be most amenable to preventative action.
- The Routine-activities approach allows analysis of the actors involved in crime and potentially involved in its prevention.

## 2.1 INTRODUCTION

The empirical work presented in this thesis is grounded in the discipline of crime science and makes use of several theoretical perspectives commonly associated with it. Section 2.2 introduces crime science and analyses it in the light of critiques made by others. The subsequent two sections are preparatory to introducing the theoretical frameworks that follow. Section 2.3 describes the idea of “good-enough” theory in criminology, while Section 2.4 outlines the meta-theoretical rational-choice perspective, which underpins both the idea of crime scripts (introduced in Section 2.5) and the routine-activities approach to crime analysis (discussed in Section 2.6).

The focus of this chapter is on describing the current state of the theories discussed, rather than on giving an historical account of their development. For accounts of the development of crime science see Laycock (2012a); the rational-choice perspective see Cornish and Clarke (2008) and Leclerc and Wortley (2014); and the routine-activities approach see Felson (2008) and Eck and Madensen (2015).

## 2.2 CRIME SCIENCE

Crime science is “the application of the methods of science to crime and disorder” (Laycock, 2005, p 4), done “ethically and with taste” (Laycock, 2008, p 149). More specifically, it is the use of such methods for “reducing crime, either by stopping it from occurring initially – prevention – or by speeding up the process of capturing those responsible after the crime has occurred – detection” (Smith and Tilley, 2005, p xix).

Within crime science there is a strong emphasis on applied research, i.e. on producing research that is relevant to preventing or detecting crime (Clarke, 2004, p 57). This has at least two consequences: firstly, it may require crime scientists to use theory and methods from other disciplines (Pease, 2010) and secondly, it may result in a body of research that is guided primarily by the needs of practice, and so is potentially less theoretically coherent than in other disciplines. In this, crime science shares principles with early work in the field of operational research (Laycock, 2005, p 4), the use of “scientific method for providing executive departments with a quantitative basis for decisions” (Kittel, 1947, p 150). The development of crime science has also often mirrored that of applied geography, “the application of geographical knowledge and skills to the resolution of real-world social, economic and environmental problems” (Pacione, 1999, p 1). In all these disciplines, what matters is producing knowledge the application of which can improve the lives of individuals or communities.

Numerous scholars have made critiques of crime science, which can be loosely categorised as abuse, misunderstandings, contextual concerns and ethical concerns<sup>1</sup>. These will be discussed in turn.

### 2.2.1 *Abuse*

Some critiques of crime science have been little short of abusive: Waddington and Neyroud (2008, p 148) noted the potential for crime science to “engender tantrums amongst some”. Zedner (2007, pp 267–8), for example, described crime science as “alarming” and a “danger” that wishes to “reduce criminology to a technicist adjunct to the security industry”, while Tabbert (2015, p 21) claimed that it “supports the idea of separating and marginalising evil groups” and Matthews (2014, p 30) characterised it as “naïve realism”. Several scholars have described it as “right wing” (Barton et al., 2010, p 25; Walters, 2013, p 19; Bowling and Sheptycki, 2015, p 278), while Hall and Winlow (2015) called it “cynical” and “defeatist”.

Walters (2013, pp 19–21) described crime science as “intolerant”, derided research by Wortley and Summers (2005) aimed at reducing prison bullying as “a high-school social studies project”, and claimed that

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<sup>1</sup> These critiques may be familiar to some readers, since many have also been levelled at situational crime prevention (SCP). For a summary and rebuttal in that context, see Clarke (2005).

“those who proselytize crime science in the UK lack the imagination, the ideological will or are unwilling to jeopardize lucrative government and private industry contracts to redirect the debate towards crimes of the powerful [and instead] target and marginalize some of the most disadvantaged and alienated citizens in contemporary western societies”.

This neglects empirical findings that the disadvantaged and alienated groups that Walters (2013, p 21) goes on to enumerate (“young people, ethnic minorities, asylum seekers, low-income earners”) often experience some of the highest levels of victimisation in the population (Sampson and Lauritsen, 1994) and stand to benefit the most from a problem-solving approach to crime reduction. Walters also assumes that crime science is uninterested in white-collar crime, despite applications of crime-science techniques across a range of criminological problems (Newman and Freilich, 2012).

There have also been personal attacks. Hope (2006, p 247) wrote that “neither Laycock nor Ekblom [two early proponents of crime science] seem capable of acknowledging, let alone explaining, the most obvious . . . evidence of crime reduction”, before accusing them of selecting “only evidence that appears valedictory”. Ironically, in the same article Hope (2006, p 246) criticised Smith and Tilley (2005, xv) for claiming that crime science had made “some criminologists apoplectic” and said that those authors had slandered him.

It should be noted that impoliteness is not limited to opponents of crime science: Waddington and Neyroud (2008, p 147) noted the “barely suppressed irritation” evident in the critique of criminology by Pease (2008). Ross (2012, p 48), meanwhile, described criminologists as producing “mostly self-indulgent waffle mixed with aching self-conscious 1960s Marxism”. Loader and Sparks (2011, p 105) quoted a “leading crime scientist” (whom they did not name) as arguing that much criminological research is “irrelevant, costly, long-winded, unreadable and totally in the self-interest of the researchers”.

From whatever source they spring, such vitriolic and personal attacks do little to further academic understanding of crime, not least because they obscure some valid points made by the same authors (which will be discussed below) and make it harder for scholars from different backgrounds to come together to discover what useful knowledge might lie between disciplinary boundaries (Brown, 2006, p 225). As Loader and Sparks (2011, p 25) noted,



the substantial effort put into abuse of academic opponents could more usefully be applied to improving the state of the art.

### 2.2.2 *Misunderstandings*

Some scholars have criticised crime science apparently based on misunderstandings about its aims or methods. Tierney (2009, p 17), for example, argued that crime science “denies access” to qualitative research methods although Clarke (2004, p 56) has urged the use of case studies while Laycock (2012b, p 2) argued *against* methodological restrictions, advocating the use of whatever method is most appropriate in a particular case. Hayward and Young (2004, p 269) argued that crime science has “an exceptional interest in maintaining rigid definitions and demarcations” between disciplines, although Laycock (2005) explained in detail how crime science seeks to break down disciplinary boundaries and look for evidence relevant to crime reduction wherever it might be found. Meanwhile Matthews (2014, p 31) claimed that crime science is methodologically unsound because it tends to conflate multiple crime categories, even though crime scientists have written extensively on the need for analysis to be crime specific (see, among many other sources almost *ad nauseam*, Cornish and Clarke, 1986, 1987; Eck et al., 2007; Cornish and Smith, 2012).

More parochially, some scholars (e.g. Hall and Winlow, 2015) have criticised crime science for seeking to marginalise or stifle criminologists whose interest lies outside the field of crime reduction. Crime scientists themselves seem divided over whether they are attempting to replace criminology (as hoped by Pease, 2010, p 18) or separate from it but maintain a constructive dialogue (as recommended by Laycock, 2008, p 150). As a matter of practice, however, there is substantial overlap between crime science and many areas of criminology (Laycock, 2011, p 721).

### 2.2.3 *Contextual concerns*

There has long been a tension in thinking about crime between those (often sociologists) who emphasise the social context of crime and those (often psychologists) who emphasise individual factors (Cullen and Wilcox, 2012; Loader and Sparks, 2012). Several sociological scholars (e.g. Hayward and Young, 2004; Stenson, 2005; Hope, 2006) have argued that crime science

ignores the important historical, social and political context within which crime reduction sits. Others (e.g. Hall and Winlow, 2015) have criticised it for being uninterested in promoting social or political revolutions that might lead to a radically improved social system. Conversely, crime science has been criticised from a psychological perspective (e.g. by Bouhana, 2013) for failing to take into account individual differences between offenders.

Whether from a sociological or psychological perspective, such critiques often stem from a perception that crime science is uninterested in explaining the distal causes of criminological phenomena (e.g. Hope, 2006, p 250). To a certain extent, the problem with this line of argument is that it criticises crime science for failing to do something that it was never intended to do: the purpose of crime science is not to explain crime but to reduce it. As Loader and Sparks (2011, p 23) put it, crime science focuses on “*how* rather than *why* crime happens” (emphasis in original).

Copson (2013, p 121) argued that it is not possible to prevent crime without understanding its distal causes. However, the substantial evaluation literature on situational crime prevention (SCP) (see Clarke, 1992, for a review) strongly suggests this argument is incorrect and it is possible to reduce crime without focusing on history, politics or psychopathology. This does not mean that understanding the distal causes of crime is not important, or that such topics should not be studied; it merely means that substantial crime prevention (the primary aim of crime science) is possible without understanding distal causes.

#### 2.2.4 *Ethical concerns*

One consequence of the de-emphasis of political and social factors in crime science is that the discipline may appear to lack an ethical compass. Muncie (2004, p 163) argued that what Laycock (2008, p 149) called the “outcome focused” nature of crime science results in a “system that has lost its way and no longer adheres to any fundamental values and principles, whether they are rooted in welfare, punishment, protection or rights”. Likewise, Treadwell (2013, p 78) expressed concern that “in its worst manifestations [crime science is] simply apologist and endorsing of state exercise of power”. To some, working with state agencies to prevent crime implicitly endorses structures and policies that are inherently cruel or discriminatory. For example, it is questionable whether it is ethical to develop techniques that will help the

police convict offenders when sentencing practices in some countries are known to discriminate against certain groups (Steffensmeier et al., 1998; Mitchell, 2005).

Critiques such as these implicitly assume that the outcome-focused nature of crime science will inevitably lead to illiberal policies (perhaps because some perceive crime science to be right-wing – see Section 2.2.1). However, there are many cases in which an evidence-based approach may lead to the repudiation of policies typically favoured by the political right: there is consistent evidence that boot camps (Wilson et al., 2005), scared-straight programmes (Petrosino et al., 2013) and the processing of youths through the criminal-justice system (Petrosino et al., 2010) are ineffective at reducing crime. However, the fact that an apolitical evidence-based approach to crime policy will sometimes lead to politically acceptable practices is unlikely to satisfy those who see crime science as potentially dangerous. The essential question remains: if the focus of crime science is on what works, then what would crime scientists do if some terrible, immoral, savage policy were shown to help reduce crime?

Laycock (2012a, p 102) answered this question directly by saying that crime science is “aimed at the prevention, disruption, or detection of crime using science *in an ethically acceptable and design sensitive manner*” (emphasis added). However, as noted by Loader and Sparks (2011, p 107), there has been little discussion of how crime science should integrate discussions of ethics or taste, beyond general statements such as “these issues need to be at the forefront of our thinking” (Laycock, 2008, p 149). The lack of the guidance that would be provided by an explicit political position (as seen in some other approaches to criminology) means that crime science must devise some other way in which to embed ethics into its practice. The “dual-use dilemma” (Karp, 1986, p 32) makes the need for such embedding particularly important, since some crime-prevention techniques may prove just as valuable to oppressive regimes seeking to prevent dissent as they are to liberal regimes attempting to prevent crime. This is not a solely theoretical concern: Rossmo et al. (2014) showed how the Gestapo used the same techniques now used to catch serial offenders to identify (and kill) political activists.

### 2.2.5 *Crime science in this thesis*

The critiques discussed here illustrate that crime science, like all approaches to the study of social phenomena, is potentially problematic in its methods and its impact. However, the harm that crime can cause in communities provides a moral imperative to take action against it. There can be no guarantees of success either in research or in policy making – any approach to reducing crime may lead to unforeseen consequences or have unwanted outcomes. This thesis adopts the crime-science approach not because it is guaranteed to be successful but because it offers the two potential benefits described above: the use of knowledge from other disciplines and the emphasis on conducting research that is useful to practitioners. Using crime science is also attractive because – as Clarke (1980a) and Pease (2008) have pointed out – so much traditional criminological research has offered little of practical value for preventing crime. Nevertheless, the use of crime science is not a guarantee of success in crime research, and so its value in this thesis will be evaluated following the presentation of the empirical results (see Section 10.1).

Just as it does not have an underlying political philosophy, crime science is not bound to a single theoretical framework: the choice of theoretical underpinning is left to the researcher. The next section will discuss how an appropriate framework might be developed, before two the frameworks that will be used in this thesis are introduced.

## 2.3 'GOOD-ENOUGH' THEORY

The nature of crime science requires a theoretical framework that can assist in solving practical problems. It might be thought that a theory is 'good' if it precisely describes the phenomenon under study, but striving for ever greater precision may lead to a theory so specific to the information used to formulate it that it does not generalise well. Theories are models of how the world works, and a model that is very accurate but not generalisable can be said to be 'overfitted': i.e. to be overly derived from "the idiosyncrasies of the sample at hand" (Babak, 2004, p 411). Generalisation requires (at least some) abstraction and this, in turn, often requires the sacrifice of some precision (Forster, 2000).

The great benefit of a generalisable theory is that it can be used to make predictions about future events. Since a theory might be able to produce multiple predictions for different purposes, if the test of the usefulness of a theory is to be its generalised predictive ability then it is necessary to specify what the purpose of the predictions will be. In crime science, the purpose of theory-based prediction is to help prevent or detect crime.

A 'good' theory for use in crime science is therefore one that provides useful information for the prevention and detection of crime. Clarke (2004, p 57) argued that all criminological theories are "provisional and incomplete", and that an emphasis on usefulness frees researchers from an unending and inevitably fruitless search for a "pure" or "true" theory<sup>2</sup>. Clarke and Cornish (1985, p 149) went further, arguing that a theory is "good enough" if it(a) is in line with the findings of existing research and (b) provides directions for either new research or policy.

Bouhana (2013, p 1) argued that such a model is "not a theory *per se*" but an "engineering heuristic" that "provides a schematic understanding" of how the world works. However, for the purposes of preventing crime this distinction may not matter, as long as the heuristic nature of good-enough theory does not prevent it from being modified in light of new evidence (Smith and Clarke, 2012b, p 296) or – when it is no longer good enough – being discarded altogether (Clarke and Cornish, 1985, p 149). According to Wortley (2014, p 237), proponents of good-enough theory could "scarcely be more explicit" that they intended to inform crime prevention rather than provide a detailed explanation of how offenders make decisions.

Taking this requirement (that a theory need only be good enough) to its logical extent suggests that as long as a theory is useful for making accurate predictions, it need not actually be based on a true understanding of the underlying mechanism that drives the phenomena being predicted. In short, a theory may still be useful even though it is known to be wrong. This may not be as controversial a position as it might first appear: Taber (2009, p 12) discussed how many scientific theories that have been superseded by more-accurate ones have still been useful for a wide range of purposes. Perhaps the most famous example of this is in physics, where the Newtonian model of the universe has been falsified during the study of objects that are moving at very-high speeds and so been replaced by the more-accurate theory of

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<sup>2</sup> The provisional nature of theory is of course not limited to the study of crime: see Smith (2000) for a summary of this discussion in the wider context of science, or Popper (2002) for an extended treatment.

relativity. Nevertheless, Newtonian mechanics are still useful for everyday calculations and so are central to disciplines such as engineering (Stirzaker, 1999, p 15). Kuhn (1970, p 76) argued against rejecting theories that produce useful results, noting that

“So long as the the tools a paradigm supplies continue to prove capable of solving the problems it defines, science moves fastest and penetrates most deeply through confident employment of those tools. The reason is clear. As in manufacture so in science – retooling is an extravagance to be reserved for the occasion that demands it.”

In discussing the theoretical framework used in this thesis, then, the standard against which theories will be judged is whether or not they provide a model of the world that is useful for the prevention of crime. The main theoretical ideas used here are crime scripts and the routine-activities approach, which rely on ideas derived from the rational-choice perspective. The next section will discuss rational choice, before the following sections consider crime scripts and routine activities.

#### 2.4 THE DECISION-MAKING CRIMINAL

Cornish and Clarke (1986, p v) introduced the concept of the “reasoning criminal” who uses “the same sorts of cognitive strategies when contemplating offending as he and the rest of us use when making other decisions”. They emphasised that, whatever social, political, psychological or biological contextual factors might influence an offender’s decisions, offending

“involves the making of decisions and of choices, however rudimentary on occasion these processes might be; and that these processes exhibit a measure of rationality, albeit constrained by limits of time and ability and the availability of relevant information” (Cornish and Clarke, 1986, p 1).

This approach conceptualised offender decisions about crime as being ‘normal’ decisions, made in the same way as decisions in other areas of life. For example, a person’s decision about what to eat on a particular evening is constrained by politics (some countries restrict restaurant opening hours), upbringing (which might influence what food someone likes), social factors (a religious person might not eat certain foods), personal preferences, the

environment (there are Eritrean restaurants in some large cities, but generally not in small towns) and financial considerations (students will not often have the resources to dine at the Ritz<sup>3</sup>). Nevertheless, a person must still decide what to eat, where and when within the constraints imposed by these contextual factors. In the same way, a potential offender is constrained by political, social, personal, environmental and financial considerations, but must still decide whether and how to offend in particular circumstances.

The rational-choice perspective has generated a substantial body of research (Farrell and Tilley, 2012, p 8) and been highly influential on crime-prevention policy (Cornish and Clarke, 2008, p 37). As such, on its own terms – those of a good-enough theory – it has been successful. Research has also shown it to be a valid descriptive model of patterns of criminal behaviour. Nagin and Paternoster (1993) and Piquero and Tibbetts (1996) found that the perceived benefits and costs of offending in particular circumstances influenced people's decisions on whether or not to offend, even after time-stable differences in self-control were taken into account. Similarly, Bachman et al. (1992) and Paternoster and Simpson (1996) – studying, respectively, sex offences and white-collar crime – found that potential offenders who did not find a particular offence morally objectionable were deterred if they believed the likelihood of being apprehended was sufficiently high. However, in both cases people who said they would not commit an offence on moral grounds were not further deterred by situational factors. Leclerc and Wortley (2014, p 5) argued that, although many early tests of the rational-choice perspective focused on property crimes, sufficient breadth of evidence now exists that the perspective can be safely applied to the analysis of any crime type.

Critiques of the rational-choice perspective have generally been of two types: the first arguing that it assumes offenders are more rational than they are, and the second arguing that an emphasis on offender decision making blames the offender for committing crimes regardless of their social or political context (for a summary of critiques of this latter type, see de Haan and Vos, 2003, pp 32–34). This second type is very similar to the contextual and ethical criticisms of crime science already discussed (see Sections 2.2.3 and 2.2.4), and so will not be discussed further here (for discussions and rebuttals of such critiques, see Cornish and Clarke, 2008; Wortley, 2010).

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<sup>3</sup> Even if they are in receipt of a research stipend.

#### 2.4.1 *Rational choice?*

It is perhaps unfortunate that Clarke and Cornish chose the term 'rational choice' for their work, since the emphasis on rationality has attracted much criticism (e.g. by Hayward, 2007). Cornish and Clarke (1986, p vi) made it clear that they chose the term only because it was already in use to describe similar ideas elsewhere, and that "adaptive choice, strategic analysis, decision making, and bounded or limited rationality" would have been equally acceptable.

Although the term rational choice is now well embedded in criminological discourse, Cornish and Clarke (1986, p vi) emphasised that they claimed offender decision making was rational only in the same way that people's day-to-day decision making is rational, i.e. that people decide on courses of action based on their perception of how best to get what they subjectively want. They also acknowledged that some offenders might appear irrational or pathological. However, they argued that even such offenders would make decisions as to how to commit a particular offence (Clarke and Cornish, 1985, p 164), and that they believed their approach to be "good enough" to model decision making as if offender's decisions "make sense to the offender and represent his best efforts at optimizing outcomes" (Clarke and Cornish, 1985, p 163). Since their model is designed for the reduction of crime (Clarke and Cornish, 1985, p 174), what is important is that committing a crime involves making a series of decisions – later conceptualised by Cornish (1994) as a crime script (see Section 2.5) – that are *to some extent* reasoned, because this suggests that it might be possible to prevent a crime if some of the factors weighing on those decisions can be changed.

The degree to which offenders are rational has been subject to some debate. Offenders must exhibit some (weak) rationality, otherwise they would be just as likely to (for example) commit a street robbery in front of uniformed police officers as in a darkened alley. At the same time offenders clearly do not exhibit perfect (or strong) rationality because there are many circumstances in which offenders' decisions turn out to be against their best interests (if there were not, prisons would be largely empty).

To establish the degree to which offender decision making is rational, it is necessary to take into account both the contextual factors that constrain decision making and the reasons why a person's decision within those constraints may be suboptimal (i.e. not objectively the best way to achieve



their goals). With one exception, the contextual factors that constrain a person's decisions are difficult to change for the purposes of crime prevention. For example, it may be – as Marxist criminologists such as Quinney (1974) have claimed – that a fundamental restructuring of the distribution of power in society would lead to a decrease in crime. However, such a change is very unlikely in many countries so seeking it would likely not be an effective way to reduce crime (at least in the short term). Because many contextual factors are so difficult to change, and both crime science and the rational-choice perspective are interested primarily in reducing crime, the influence of those factors on criminal decision making will not be discussed in detail here. The exception is the construction of the local environment in which a person contemplates committing a crime – the influence of situation on criminal decision making will be discussed in Section 2.6.

#### 2.4.2 *The normality of sub-optimal decision making*

Why might an offender make a decision that is apparently irrational, within the constraints of context? Answers to this question can be broadly divided into those relating to failures of information and to failures of information processing.

Failures of information relate to an offender having imperfect knowledge of their situation, i.e. not knowing things which would help in making a decision relating to a particular crime. For some offences, a proportion of offenders will not know that their conduct constitutes an offence (Low, 1988, p 551). More often, offenders will incorrectly estimate the likelihood of being apprehended for a crime, although habitual offenders are likely to have more accurate perceptions than occasional ones (Saltzman et al., 1982). Once apprehended, it is also common for people to misperceive the likely sentence for a particular offence (Hough and Roberts, 1999).

As well as these general failures of knowledge about the criminal justice system, offenders may have imperfect knowledge of the immediate situation in which they commit an offence. Returning to the earlier example, the offender who chooses to commit a robbery in a darkened alley rather than in front of uniformed police officers may not know that the person walking through that alley is an undercover officer engaged in a sting operation. Alternatively, the offender may not know that their intended escape route is blocked by construction work, or that there is no money in the victim's purse,

or innumerable other things that might have influenced their decisions had they known them.

Even if an offender has perfect information about a situation, there is ample evidence that a typical offender (indeed, a typical person in society) is not able to process that information with perfect rationality. Much of this evidence comes from the field of behavioural economics, the study of the cognitive influences on decision making, associated most often with the prospect theory of Kahneman and Tversky (1979). The central idea of behavioural economics is that instead of making decisions based on a careful balancing of cost and benefit, people make decisions using heuristics, strategies that involve ignoring some of the information that is available to the person “with the goal of making decisions more quickly, frugally, and/or accurately than more complex methods” (Gigerenzer and Gaissmaier, 2011, p 454). Estrada (2001, p 2) argued that behavioural economics replaces the central assumption of classical economics that people make decisions rationally with an assumption that people make decisions in a “normal” way<sup>4</sup>.

There are many examples of cognitive biases and heuristics – Olsen (1998) listed 40 – several of which may be relevant to decision making by offenders. Confirmation bias, for example, describes the tendency of people to overweight information that confirms their pre-existing beliefs and underweight information that is contrary to those beliefs (Nickerson, 1998). This could potentially explain the findings of de Haan and Vos (2003) that, once they had decided to commit a particular offence, the street robbers they interviewed were unlikely to be dissuaded by new information. Similarly, below a certain threshold people appear to be insensitive to changes in the probabilities of unlikely events, such that they do not discriminate between (for example) a 1 in 100,000 chance and a 1 in 10 million chance of a negative event occurring (Kunreuther et al., 2001). This could explain why Kelling et al. (1974) found that doubling police patrol in an area had no impact on street crime, because offenders may have simply discounted the increase as “doubling a drop in the bucket” (Felson and Boba, 2010, p 7).

Of potential importance for crime prevention is the evidence that people’s reliance on decision-making heuristics can be varied by making changes to

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<sup>4</sup> In this respect, it should be noted that the rational-choice perspective on crime reduction has integrated the concept of heuristics from the beginning. Cornish and Clarke (1986, p v) emphasised that their perspective assumed that decisions about offending were made using the same cognitive strategies as any other type of decision, and included a chapter (Lattimore and White, 1986) in that edited collection surveying what was known about heuristics at the time.

the environment. Many offender decisions – as well as decisions by potential victims that might influence the likelihood of their being victimised – are made under time pressure or other stress, which Keinan et al. (1987) found was associated with a decrease in the quality of people's decision making. This may therefore help explain both the apparent poor quality of some offender decision making and highlight the potential importance of removing or reducing time pressure in order to promote good decision making by people at risk of victimisation. Similarly, Malhotra (1982) found that information overload could lead to poor decision making, which suggests that crime-prevention publicity campaigns should focus on providing clear and simple messages (as recommended by Barthe, 2006).

A person's cognitive ability is also influenced by biological factors. Alcohol intoxication has been shown to be associated with greater aggression (Giancola et al., 2010) and a lower ability to consider the potential costs of committing offences (MacDonald et al., 1995). This "alcohol myopia" (Steele and Josephs, 1988) appears to result from intoxication leading to people being more responsive to cognitive cues that encourage deviant behaviour (Giancola et al., 2011), such as another person arguing with them, and failing to consider the future consequences of their actions (Bushman et al., 2012). Increased aggression has also been found in intoxication due to benzodiazepine abuse (Albrecht et al., 2014)<sup>5</sup>, while addiction to cocaine or heroin is associated with poorer decision making (Brand et al., 2008; Hulka et al., 2013). A range of physical and mental health conditions can also be associated with impaired decision making, and there is evidence that people make poorer decisions while emotionally aroused (see Wortley, 2014, p 245, for a review).

Failures of information (i.e. of knowledge) or of information processing may make it appear to an external observer that an offender's decision to commit a crime, or to commit it in the circumstances in which they did, is irrational. However, this does not mean that (a) the offender did not make decisions in relation to the commission of that offence, (b) those decisions were not made based on the offender's perception of the information available at the time, or (c) those decisions were not made with the aim of achieving the offender's preferred outcome at the time. If those statements remain true, then it remains possible to think of a reasoning criminal.

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<sup>5</sup> Note, however, that the relationship between phencyclidine (PCP) and aggression may have been overstated (Hoaken and Stewart, 2003, p 1545) and cannabis use appears to be associated with decreased levels of aggression (Myersough and Taylor, 1985), despite the moral panics about the use of both drugs described by Goode and Ben-Yehuda (2009, pp 199–207).

### 2.4.3 *Being crime specific*

One important consequence of the rational-choice approach is the need to study specific types of crime rather than crime in general (Cornish and Clarke, 2008, pp 26–27), because a reasoning criminal is likely to make decisions that are crime specific (Cornish and Clarke, 1987, p 935), for at least two reasons. Firstly, the preferred outcome that they seek is likely to vary according to the type of offending. For example, someone who robs a rival drug dealer to obtain his money has a different goal from one who robs the rival in order to steal his drugs to put him out of business, or to exact revenge for perceived misdeeds<sup>6</sup>. Secondly, the influence of circumstances on the chance of the offender achieving their preferred outcome is likely to depend partly on the nature of the crime being committed. For example, the weather may be an important situational determinant for people who steal money from others on the street (Tompson and Bowers, 2013a), but is unlikely to be important for offenders who steal money from others online.

In adopting a crime-specific approach to analysing crime, it is often insufficient to simply adopt legal classifications of offences (Goldstein, 1979, p 245; Cornish and Clarke, 1986, p 2) because of the variation within each class. For example, robbery is typically reported in official statistics as either a single category of crime (e.g. by Boyce, 2015 for Statistics Canada or Clarke, 2013 for Eurostat), or is differentiated only according to whether the victim was an individual or a business (Office for National Statistics, 2015a, p 31) or whether a weapon was used (Australian Institute of Criminology, 2014, p 26). However, within these categories there are likely to be many types of robbery with a wide range of characteristics. For example, the category of personal robbery might include offences targeting people on the street (Monk et al., 2010) or at automated teller machines (Scott, 2001), robberies of taxi drivers (Smith, 2005), car jackings (Jacobs et al., 2003), home invasions (Heinonen and Eck, 2012), any many other types of crime. It appears unlikely that the influence of circumstances on offender decision making would be the same across all types of robbery, and therefore it is necessary to disaggregate them when data-availability and other constraints allow. The importance of doing so can be seen from the results of studies that have shown variations in the spatial concentrations, temporal trends, victim characteristics and likelihood of fatal injury associated with different types of robbery (e.g. Cook, 1987;

<sup>6</sup> Robberies of drug dealers for all of these reasons appear to be common (Topalli et al., 2002; Deakin et al., 2007), and are a substantial cause of drug-related murders (Goldstein et al., 1989).

Matka, 1997; Dauvergne, 2010; Braga et al., 2011; Andresen and Linning, 2012). The importance of being crime specific also explains the value of studying new crime problems such as metal theft. Such studies may reveal features of a crime that are specific to that problem and in doing so help define the limits of the applicability of previous research.

Having introduced the rational-choice approach, the following two sections will introduce two theoretical frameworks that are underpinned by it and which will be used as the foundation for the empirical work presented in subsequent chapters. Section 2.6 will discuss the routine-activities approach, after the concept of a crime script is introduced in Section 2.5.

## 2.5 CRIME SCRIPTS

Any crime involves a series of actions that together make up a process, which will be different for each type of crime. Cornish (1994) adapted the concept of cognitive scripts – initially developed in the field of psychology by Schank and Abelson (1977) – to analyse the different units of common crime processes, in order to better identify the points at which potential controllers against crime (see Section 2.6) can intervene to prevent an offence occurring<sup>7</sup>. Although there have been some criticisms of how applicable the details of the script concept – as understood by psychologists – are to the prevention of crime (Ekblom and Gill, 2015), the idea of identifying and analysing the constituent parts of a crime process appears valuable (Duijn et al., 2014, p 3) and has been successfully used in research on crime prevention (e.g. Hancock and Laycock, 2010; Brayley et al., 2011; Chiu et al., 2011).

Scripts are regularised abstractions of sequences of behaviour that people carry out in their everyday lives (Schank and Abelson, 1977; Ekblom and Gill, 2015). They capture the fundamental constituent activities that must be completed as part of common procedures. For example, in order to travel to work by train a person must (among other things): enter a railway station, find out when their train departs, purchase a ticket, use the ticket to pass through any ticket gates, find the appropriate platform and board the train. While the actual sequence of activities that the person completes may vary

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<sup>7</sup> Crime scripts have also been referred to, particularly in crime analysis conducted by police forces, as “criminal business profiling” (Brayley and Cockbain, 2011, p 133). Various terms have been used for the component parts of crime scripts, often using theatrical analogies (e.g. Tompson and Chainey, 2011), but this thesis will use the terminology (“units”) recommended by Ekblom and Gill (2015).

from day to day (for example if they sometimes stop for a newspaper before going to the platform), the fundamental activities that make up the train-boarding script are likely to remain the same in most cases (Hancock and Laycock, 2010, p 173).

Scripts can be used to analyse crimes at different levels of abstraction. Here there is a tension between being as precise as possible in order to realise the benefits of being crime-specific while also not being so specific as to reduce the value of the script for analysing future crimes that are not exactly the same as those that have occurred before (Borrion, 2013; Ekblom and Gill, 2015). Cornish (1994, p 159) described five levels of abstraction: universal scripts, metascripts, protoscripts, scripts and tracks. However, there does not appear to be anything distinguishing these categories other than their ordering: for example, the only thing distinguishing tracks and scripts is that different tracks nest within a single script, but this relationship could equally be described by designating the tracks and scripts and saying that they nest within a single protoscript. Nor does there appear to be any indication that the optimum number of levels of abstraction is five: in some cases more may be required and in some cases fewer will be sufficient. For these reasons, nested units will not be referred to using these terms in the analysis that follows.

The script analysis of crime allows the identification of three features of crime processes that are relevant to crime prevention: (a) the units of a crime process are often dependent upon one another, (b) they are often dependent upon external actors, resources, locations and so on, and (c) they have the potential to exhibit regularity, with future crimes likely to resemble previous ones. Although often represented visually as a simple sequence of steps, it is not true that a crime process is always a purely linear progression from beginning to end (see, for example, the scripts developed by Brayley and Cockbain, 2011, p 136 and Savona et al., 2014, p 149). However, it is often true that a particular step cannot be undertaken until some previous steps have been completed. For example, a jewel thief cannot sell on stolen diamonds (however skilled and practiced they are at doing so) until they have cracked the safe in which those diamonds are stored. Similarly, they will not be able to crack the safe without the necessary tools, or dispose of the jewels without access to a willing and capable fence (Ekblom and Tilley, 2000).

It is the dependency of units on one another that makes script analysis valuable for crime prevention, since if an essential part of the crime process

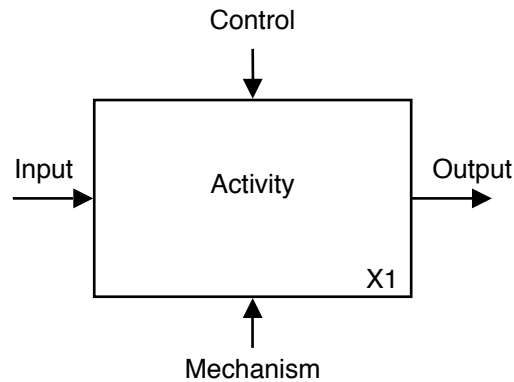
can be interrupted then the entire process will stop and the crime will be prevented. For example, if a safe can be hardened successfully against the jewel thief's attacks then the crime will be prevented, however adept the thief is at the other units in the crime process. These vital units are the "pinch points" (Pease and Farrell, 2014, p 77) of the crime process that present opportunities to prevent crimes from occurring.

The value of crime scripts depends upon criminal behaviour exhibiting regularity, such that (at least some of) the processes by which future offences will occur can be predicted from those observed in previous instances. Cornish (1994, p 157) argued that the crime processes used by particular offenders are likely to become habit forming, such that a frequent offender may give little thought to how they commit a particular offence in circumstances similar to those in which they have often offended previously – an example of the heuristic decision making discussed in Section 2.4.2. While vulnerable to all the well-known shortcomings of inductive reasoning (for which, see Fisher, 1935; Popper, 1972), in practice it appears that offenders do have usual means of committing a crime (Nee and Meenaghan, 2006), making it possible to predict with some accuracy their future offending based on past behaviour.

#### 2.5.1 *Constructing a crime script*

Crime scripts are increasingly widely used in crime analysis, but until recently there have been few standard sources of data (Hutchings and Holt, 2015, p 599) or methods (Brayley and Cockbain, 2011, p 133) for script construction. Thompson and Chainey (2011) suggested a structured method consisting of four steps: identifying the units that make up a script, describing the actors, tools and activities involved in each unit, interpreting and visualising the results, and finally using the results to identify actions to prevent the crime occurring. They also proposed seven foci for analysis of each unit: (a) the function of the unit within the script, (b) the actors involved, (c) the activities undertaken, (d) the prerequisites for those activities to occur, (e) the facilitators that make a unit more likely to occur, (f) who has responsibility for regulating the activity and (g) what regulations govern the activity (Thompson and Chainey, 2011, pp 188–190).

To situate each unit within a script (focus (a) above), Thompson and Chainey (2011, pp 188–189) categorised units as involving preparation, pre-activity, activity or post-activity relative to the occurrence of the crime in question.

Figure 2.1: *Example IDEF0 representation of an activity.*

Perhaps confusingly, the “preparation” unit involves actors becoming aware of opportunities to offend, while the “pre-activity” unit involves “logistical or transactional steps that need to be carried out prior to the activity” (which might commonly be termed preparation).

One limitation of the four-step process proposed by Thompson and Chainey (2011) is that it does not include any mechanism for testing the accuracy of the resulting script. Borrion (2013) emphasised the importance of validating whether a script is accurate enough to be used to identify potential crime-reduction measures. He argued (p 5) that this is particularly important in the context of “good-enough” theory, since without validation any model might be assumed to be good enough simply because it is derived from empirical data. To counter this problem, Borrion proposed a quality-assurance checklist for crime scripts (summarised in Table 2.1) that seek to apply basic principles of scientific practice – for example the requirement to describe methods used. However, to date there have been no empirical applications of this checklist of which the author is aware, and so its value is as yet uncertain.

The checklist in Table 2.1 requires that the visual representation of a crime script should be consistent throughout the process, but there is no prescription as to what that consistent representation should be. Previous researchers have shown scripts in a variety of ways, including narrative description (Hutchings and Holt, 2015), tables (Cornish, 1994, p 161) and flow charts (Brayley and Cockbain, 2011, p 136; Thompson and Chainey, 2011, p 196), but at present there appears to be no standard way of displaying a script.



Table 2.1: *Checklist for quality assurance of crime scripts.*

Adapted from Borrión (2013, pp 8–9).

Typology	It should be clearly indicated whether the script relates to observed or potential actions, and which actor (offender, victim etc.) the script seeks to analyse
Traceability	The relationship between elements of the script and the objective of the script, and relationships between elements, should be explicitly stated
Transparency	The method used to develop the script should be explained
Consistency	The method, terminology and visual representation should be consistent through the script
Context	In order to allow appreciation of potential external influences and constraints, the context in which the script operates should be stated
Completeness	Although a script will always be incomplete, for each activity the script should describe the main factors influencing potential outcomes (using the foci of analysis described by Thompson and Chainey, 2011, pp 188–190)
Parsimony	The script should only include information that is relevant for the specific purposes for which the script is required
Precision	The script should be sufficiently precise to produce information at a level of abstraction that is useful to decision makers
Uncertainty	It should be stated what degree of uncertainty is associated with each piece of information in the script, and whether the information is derived from observation, inference, simulation, speculation etc.
Usability	The script should contain sufficient information to be useable, and be presented so as to be intelligible, by decision makers
Ambiguity	So far as is reasonably foreseeable, the information in the script should not be open to misinterpretation
Accuracy	The elements in the script and the relationships between them should be accurately described, within the bounds of available knowledge

The visual representation of crime scripts could potentially be improved by integrating knowledge from the domain of systems engineering, in which the problem of representing processes have been extensively studied and is known as business process modelling (BPM) – for an introduction, see Bridgeland and Zahavi (2009, Chapter 5). Several visual languages exist for the description of functional processes (for comparisons, see Carnaghan, 2006; Businska et al., 2013), many of which have features that may be useful in the development of crime scripting. Although applications of BPM in relation to crime are rare – those few that do exist include Cotofrei and Stoffel (2011) and Bukhsh (2015) – work in the field could help in providing greater structural rigour to the representation of crime scripts.

The crime script described in Chapter 6 of this thesis will use the Integration Definition for Functional Modeling (IDEF0) system (National Institute of Standards and Technology, 1993) for representing the process of metal theft. Each unit (known in IDEF0 notation as a *function*) within an IDEF0 model is represented by a box linked to other parts of the script by one or more arrows (Figure 2.1). Crucially, the point at which arrows enter or leave a box denotes the role that the quantity represented by the arrow plays with respect to the function represented by the box itself. Arrows entering boxes from the left represent inputs to the function, i.e. things that are transformed in some way by the function. Arrows leaving boxes to the right represent outputs from the function, i.e. the product that results from the function transforming the inputs. Arrows entering boxes from the top represent “controls”: factors that influence the operation of the function in some way. Finally, arrows entering the box from the bottom represent the mechanisms by which the function transforms the inputs into the outputs, including the resources required (for a more-detailed description, see National Institute of Standards and Technology, 1993).

This structured method for representing the factors influencing the performance of a function within a script is one of the main strengths of IDEF0 notation (Kamath et al., 2003, p 7), because it requires the modeller to explicitly consider all four types of factor (input, output, control and mechanism). In the case of crime scripts, IDEF0 notation requires the analyst to undertake structured consideration of all three of the script elements – activities, the actors who carry them out and the context in which they occur – and the seven foci of analysis described by Thompson and Chainey (2011, p 189).

As will be discussed in Section 6.4, IDEF0 notation also helps satisfy the quality-assurance tests set out by Borrion (2013)<sup>8</sup>.

Whether crime scripts are the optimal procedure for analysing crime processes is an open question, and one that has been asked only infrequently. However, it appears that – in the absence of alternative procedures – they have been good enough for use in those studies that have applied them. As such this thesis applies a crime-script analysis to metal theft, using the procedure proposed by Thompson and Chainey (2011) and supported by use of the checklist proposed by Borrion (2013). The resulting script will then be used to identify further analysis that might usefully add to existing knowledge of the problem of metal theft, or offer potential means by which such thefts could be prevented.

## 2.6 THE ROUTINE-ACTIVITIES APPROACH

Having outlined crime scripts as a tool for modelling the process of committing a crime, this section will describe a model for understanding the units within that process, i.e. what factors must come together in order for that crime to happen. The most well-developed theory of criminal events is the routine-activities approach, which attempts to describe those people, objects and circumstances that must coincide in space and time in order for a crime to occur. There is no single text setting out this approach in its entirety: first devised by Cohen and Felson (1979), it has been further developed by (among several others) Felson (1986), Eck (1994), Eck and Weisburd (1995) and Sampson et al. (2010), with the latest iteration being that outlined by Eck and Madensen (2015).

The main focus of the routine-activities approach is the criminal *opportunity*. An opportunity is said to occur when a *motivated offender* and a *suitable target* meet in the same *place* at the same time, in circumstances in which potential *controllers* do not prevent the opportunity arising. Targets may be either people or objects (broadly defined – see Section 2.6.2), depending on the type of crime.

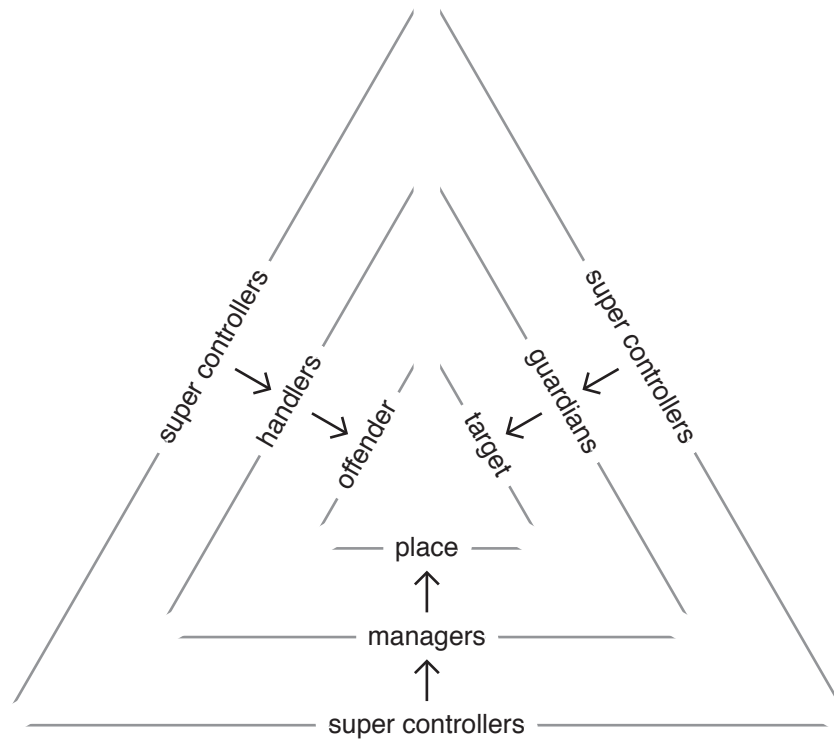
Controllers (Eck and Weisburd, 1995, p 5) are individuals who provide informal social control in relation to targets, offenders or places (Reynald, 2014,

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<sup>8</sup> Although IDEF0 modelling has the potential to be useful in representing crime scripts, it does not necessarily follow that the greatest benefit would be obtained by wholly replacing current crime-scripting practice with every aspect of the IDEF0 modelling process regardless of its suitability. In particular, the somewhat esoteric system for numbering IDEF0 activity boxes has not been used here, since it would likely sow more confusion than understanding.

Figure 2.2: *The crime triangle.*

The innermost triangle – originally referred to as the problem-analysis triangle – was first published by Eck (1994) and has been expanded with the addition of further elements to the routine-activities model. For the history of the development of the triangle, see Eck (2003) and Eck and Madensen (2015).



p 2482). *Handlers* control offenders, for example by reducing their motivation or preventing them from coming into contact with a target (Felson, 1986). Similarly, *guardians* control targets, either by reducing their vulnerability or preventing offenders from coming into contact with them (Cohen and Felson, 1979). Thirdly, *managers* control places to make them less suitable for offenders and targets to co-incide in (Eck, 1994). The final role in the model is that of a *super controller* (Sampson et al., 2010), people or groups that create incentives that influence the behaviour of controllers. The overall model is shown in Figure 2.2, with arrows showing the main influencing relationships. However, this is a simplification: in reality there are likely to be many relationships between actors throughout the model.

Two general features of the model should be emphasised. The first is that there may (and often will) be multiple controllers and super controllers in each category for each target, offender and place. For example, a typical

Table 2.2: *Types of offender–target relationship.*  
Adapted from Felson (1987, p 912).

Exploitative	At least one offender acts against at least one target, where the target (or its owner) is opposed to the offender's action, e.g. a robber who steals from an unwilling victim.
Mutualistic	Multiple people act in concert to commit an offence, e.g. a drug dealer and a drug user both wish to transact drugs.
Competitive	Multiple people act in the same way in opposition to one another, e.g. two people fighting in the street.
Individualistic	A single person acts against themselves, e.g. a person using illegal drugs.

offender will have multiple family members, friends and others who can influence their motivation to commit crimes in particular circumstances. The second is that the human elements described in the model – offenders, targets, handlers, guardians, managers and super controllers – are roles, rather than necessarily being separate actors. Eck and Madensen (2015) described how actors can fulfil multiple roles, either at different times or even in respect of the same crime. For example, a warehouse security guard (fulfilling the role of a guardian) might agree to leave a door unlocked to allow access to burglars (making her an offender). Conversely, a bus driver (a potential place manager) might also become a victim if they are assaulted onboard their bus (for other examples of such overlap, see Smith, 2014, pp 349–350). There has been some disagreement in the literature about whether this crossover extends to a person being a guardian with respect to themselves (Reynald, 2014, p 2488). Hollis et al. (2013, p 74) argued that conceptual clarity requires guardians to be third parties, with self-protective behaviour being better described as target hardening. However, this latter term has been commonly used to refer more-specifically to the physical strengthening of security around inanimate objects at risk of becoming targets for theft or damage (see, for example Mayhew, 1984; Clarke, 1997). In contrast, Sampson et al. (2010, p 44) argued that “much guardianship is self-guardianship – people taking action to protect themselves”. In practice, the analytical distinction between targets and guardians may be immaterial in cases of self-protection, as argued by Cohen and Felson (1979, p 590).

The terminology used in the routine-activities approach – particularly the concepts of “offender” and “target” – may suggest that the approach

is only useful for explaining the types of predatory crime (i.e. offender attacking target) in relation to which it was first developed. Felson (1987, p 912) outlined four types of offender–target relationship (Table 2.2) and argued that the routine-activities model can be applied to them all. For example, in a competitive offence such as two people fighting in the street, the main components of the model still apply: the two people must come together in a place and their behaviour can be affected by the action or inaction of controllers. It matters little whether the potential controllers of the two actors in the fight are analysed as handlers or guardians, since the analytical result is likely to be the same<sup>9</sup>. For similar reasons, a drug transaction can be analysed using the routine-activities model, even though both the seller and purchaser are targets (in that the other person seeks them out) and offenders (in that their conduct is illegal). The process of stealing metal is likely to involve exploitative offences such as a theft itself and mutualistic offences such as the fencing of stolen metal. It may also involve individualistic offences such as trespassing on railway tracks, where the person put at most risk is the offender themselves.

A key feature of the model, and that which gives it its name, is that the likelihood of a person being involved in a particular crime is dependent partly upon the activities in which they are commonly involved. Cohen and Felson (1979, p 593) defined routine activities as “recurrent and prevalent activities which provide for basic population and individual needs” that are “a part of everyday life”, such as shopping, going to work or visiting friends. Such activities are relevant to crime because, for example, a person who frequently goes to bars as part of their leisure activities is more likely to have their bag stolen while in the bar than a person who only goes to bars infrequently. Although a micro-level theory of human behaviour, the patterning of routine activities in society means that changes in such activities can influence crime trends at a macro level. Several scholars (e.g. Cohen and Felson, 1979; Cohen et al., 1980; Cohen, 1981) used the example of the increasing number of women working outside the home in the United States (US) in the second half of the Twentieth Century and showed that this could be used to explain increases in the frequency of domestic burglary. They argued that this change in the routine activities of those women (going to work in the day rather than being at home) had led to a decrease in daytime

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<sup>9</sup> An alternative analytical technique would be to wait until the fight had finished and then apply the police maxim that “the loser goes to the hospital, and the winner goes to jail” (Bacon, 2009, p 197; see also Felson and Boba, 2010, p 34), treating the less-injured party as the offender and the more-injured party as the target.

guardianship in those homes, producing more opportunities for crime. It is also likely that patterns of routine activities exist among crime controllers – Ashby and Tompson (2015) found that such patterns accounted for the majority of temporal variations in police searches of suspects.

The following sections will consider each element of the routine-activities model in turn, before discussing some implications of the model and a number of critiques of it.

### 2.6.1 *Offenders and their handlers*

Early descriptions of the routine-activities approach took offenders for granted (Felson, 1995, p 54; Tillyer and Eck, 2011, p 183) simply assuming that there was a sufficient supply of motivated offenders to exploit crime opportunities. Later work modified this position, but the analysis of offenders in the routine-activities approach remains circumscribed. In particular, the approach is not *primarily* concerned with how people develop time-stable inclinations in relation to crime, or what influences variations in such inclinations between people (Felson, 1986, p 120), although it may consider the consequences of such differences. Instead, the focus is on how the opportunity structures within which people exist influence their ability to act upon their desires and inclinations.

Evidence for the importance of routine activities in determining the extent to which people are likely to offend can be found in studies of changes in criminal behaviour associated with changes in routine activities. Warr (1998) found that changes in routine activities associated with offenders getting married were associated with decreases in the frequency with which they offended. More generally, Horney et al. (1995) found that life events such as starting or stopping work, education, probation, heavy drinking or illegal drug use were all associated with changes in offending frequency (for a review of similar studies, see Siennick and Osgood, 2008).

Eckblom and Tilley (2000) considered what factors might influence the ability of a potential offender to commit crime, factors that they referred to as resources, divided into five categories. *Personal* resources refer to time-stable physical and personality attributes, as well as personal preferences (for example in regard to the risk of apprehension). *Moral* resources capture how

an offender neutralises any issues of morality related to their offending<sup>10</sup>. *Cognitive* resources refer to an offender's knowledge of the skills required for an offence, which may change over time as a result of learning or in response to changing circumstances. *Facilitatory* resources are physical things such as weapons or vehicles that an offender may require. Finally, *collaborative* resources are an offender's ability to join their own capabilities with those of others to make offences possible. Different combinations of resources are required for different types of crime, but a lack of necessary resources (for example lack of the knowledge to distinguish between copper and fibre-optic railway cable) may prevent a motivated offender from successfully exploiting a particular crime opportunity.

Felson (1986) argued that the behaviour of almost all offenders can be influenced through informal social control, the processes by which individuals and groups in society influence one another to conform to particular norms (for a recent review of this concept, see Groff, 2015, pp 91–94). However, he also argued that the ways in which offenders can be influenced vary between individuals. The control “handles” that can be pulled, and which “handlers” can effectively pull them, are unique to each offender. For some people, the prospect of admonishment by passers-by will be sufficient to prevent them from offending, while for others only the opprobrium of a close relative will have any effect. Crucially, the ability of handlers to control offenders is likely to vary systematically, which can be used to help explain systematic variations in the frequency of crime. For example, schools generally close before most workplaces, leaving an afternoon gap when in-work parents cannot act as handlers for any potential offenders among their school-aged children (Soulé et al., 2008). Similarly, offenders who have access to a car may be more likely to spend time in places away from potential handlers such as their parents, decreasing the ability of those handlers to control them (although this relationship may be more complicated: see Bichler et al., 2012).

Osgood et al. (1996) tested the hypothesis that control by effective handlers will help to prevent offenders from committing crime. They found that a substantial proportion of differences in self-reported criminal behaviour of 18- to 26-year-olds could be explained by variations in the amount of time that they spent in unstructured socialising with peers in the absence of potential controllers, with more such time being associated with more criminal behaviour. Other studies have found similar relationships in younger

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<sup>10</sup> Neutralisation is a large area of research that is beyond the scope of this thesis. For reviews, see Maruna and Copes (2005) and Copes (2014).



teenagers (Mahoney and Stattin, 2000; Bernburg and Thorlindsson, 2001) and pre-teens (Maimon and Browning, 2010), although they have also emphasised that individual-level variations (for example in impulsiveness) meant that not all offenders are influenced by unstructured socialising to the same extent. Osgood and Anderson (2004) found that parental monitoring was particularly important in explaining teenagers' involvement in crime, suggesting that controllers with personal responsibility are likely to have a disproportionate influence. Once offenders are older, Warr (1998) found that most of the decrease in offending associated with marriage could be explained by a coincident decrease in unstructured socialising. Overall, it appears that there is empirical support for the influence of handlers on offenders.

### 2.6.2 *Targets and their guardians*

The term 'target', rather than 'victim', is used deliberately in the routine-activities approach because, for many crimes, offenders will be indifferent towards the individual who would be considered by law to be the victim (Felson, 2004, p 123), except so far as that person might be able to act as a guardian. For many property crimes, the offender may even be entirely ignorant of the victim, for example in the case of an overnight burglary at a shop or the theft of items from a parked car. This is likely to be particularly true for corporate victims such as railway companies: outside of their role as potential controllers, metal thieves are likely to be more focused on the target of vulnerable metal than the victim who owns it. Focusing on the prevention of the criminal event therefore requires emphasis on the target that the offender seeks and with which he or she must come into contact in order to complete the offence. Early work on the routine-activities approach concentrated on object targets, particularly those at risk of theft. More recent work has also considered human targets of assault (Kennedy and Forde, 1990; Roncek and Maier, 1991), sexual harassment (De Coster et al., 1999), fraud (Holtfreter et al., 2008; Pratt et al., 2010) and cyberstalking (Holt and Bossler, 2008; Reyns et al., 2011) as well as intangible targets such as the use of services without payment (Miller, 2012) and the various targets of white-collar crime (Benson et al., 2009).

In order for an offence to occur, the routine-activities approach argues that a target must be "suitable" (Cohen and Felson, 1979) or, more importantly, that an offender *perceive* the target to be suitable (Groff, 2007, p 82; Hollis

et al., 2013, p 67). Cohen et al. (1981, pp 507–508) divided suitability into the “accessibility” and “attractiveness” of a target to an offender, with Bennett (1991, p 148) subsequently sub-dividing accessibility into the ease with which an offender can come into contact with a target and the degree of “inherent resistance of the [target] to attack”. The notion of suitability has received more-detailed consideration in relation to physical targets of crime. Cohen and Felson (1979, p 591) described target suitability as depending upon “value . . . physical visibility, access, and the inertia of a target against illegal treatment by offenders”, later summarised by Felson and Clarke (1998, p 5) as value, inertia, visibility and access (VIVA). Clarke (2000) extended this, defining the suitability of property targets according to the degree to which they are concealable, removable, available, valuable, enjoyable and disposable (CRAVED), a framework described more fully relation to metal theft in Section 3.3.

Although it was stated in Section 2.6 that guardians are individuals who protect targets, there has been substantial academic disagreement about the nature of guardianship. Hollis et al. (2013, p 76), in a recent reappraisal of the concept, defined guardianship as the presence of any third party that prevents an offender accessing a target, regardless of whether their focus is on control of the offender, the place or the target (thereby subsuming the concepts of offender handlers and place managers). However, this is somewhat at odds with how guardianship has been defined elsewhere in the literature (e.g. by Sampson et al., 2010, p 39; Hollis-Peel and Welsh, 2014, p 322; Miró, 2014, p 4), where the term has been used specifically to refer to people who control targets. Hollis et al. (2013, p 73) also argued that “guardians are individuals who are present and it is *by this presence alone* that they deter the would-be offender” (emphasis added). However, such a conception of guardianship has the potential to severely limit the degree to which the routine-activities approach can be used to analyse criminal events, for at least three reasons. Firstly, the stipulation that “presence alone” makes a guardian appears to prohibit consideration of potential variations in responsibility and capability (for the importance of which, see Reynald, 2009). Secondly, the requirement for presence is ambiguous, leaving open the question of whether, for example, a parent in the next room (or at the other end of a phone) might be a capable guardian. Thirdly, requiring a guardian to be present leaves the model unable to analyse an actor who takes steps to protect a target that do not involve them being present to prevent offenders

accessing a target. Take, for example, staff at an infrastructure provider that bury copper cable to make it more difficult to steal. If such staff cannot be considered to be guardians because they are not present at the time an offender tries to access the metal, how can their role be analysed within the model? And what value is added to the model by requiring a guardian to be someone who is physically present?

In order to avoid these limitations, in the following chapters the term guardian will be used to describe people who prevent crimes by protecting targets. This leaves open the question of *how* guardians do this. Reynald (2009) argued that in order for guardians to be effective, they must(a) be available, (b) engage in monitoring or supervision of potential targets and (c) be willing to take action to protect targets where necessary. Based on interviews with potential guardians against residential burglary, Reynald (2010) refined these requirements, concluding that the effectiveness of guardianship was dependent upon a potential guardian's willingness to monitor a target, ability to detect offenders and willingness to intervene. This study also emphasised the importance of factors such as responsibility, competence and the availability of tools to assist with guardianship (Reynald, 2010, p 380).

Numerous studies have shown guardianship to be an important determinant of the frequency of crime. Early studies were conducted at the macro level and concentrated on guardianship against property crime. Several (e.g. Cohen and Felson, 1979; Cohen et al., 1980; Cohen, 1981; Stahura and Sloan, 1988; Bennett, 1991) operationalised guardianship as the proportion of women in the labour force, arguing that women who were working were not available to act as guardians against burglary at home. Similarly, others (e.g. Felson and Cohen, 1980; Miethe et al., 1990) measured burglary guardianship as the inverse of the number of people living alone. These studies showed that the frequency of residential burglary went up as the number of people at home decreased.

Miethe et al. (1991) argued that these macro-level measures of guardianship were inadequate and insufficiently clear about the distinction between, for example, guardianship and target suitability. Subsequent studies, still focused on residential burglary, used more direct measures of guardianship. For example, Garofalo and Clark (1992) used surveys to determine whether a person was likely to be at home during daytime and evening periods, while Coupe and Blake (2006) used victim interviews to gather similar data. These studies, too, found that victimisation tended to increase as guardianship de-

creased, but provided only limited information on the mechanisms by which guardianship operates (Reynald, 2010, p 360). Tests of the guardianship-in-action model proposed by Reynald (2009) have recently begun to shed light on this issue. For example, Reynald (2009), Reynald (2011) and Hollis-Peel and Welsh (2014) found empirical support for distinguishing between a guardian being available to protect a target, their engaging in visible monitoring of the target and their intervening upon observing suspicious behaviour. Overall it appears that there is empirical support for variations in target suitability and guardianship explaining (at the macro level) variations in the frequency of crime and (at the micro level) the likelihood of a particular target being victimised.

### 2.6.3 *Places and their managers*

Places in the routine-activities approach are

“specific locations within the larger social environment. They can be as small as the area immediately next to an automatic teller machine or as large as a block face, a strip shopping center, or an apartment building” (Eck and Weisburd, 1995, p 3).

Eck (1994, pp 10–13) argued that places have five features: (a) a defined location, (b) commonly-understood boundaries, (c) one or more dominant functions, (d) a person or group with control over its use, and (e) a small size usually between that of an apartment and a street segment. The small size of places is particularly important because it is in relatively small areas (such as at bus stops, in houses or outside convenience stores) that potential offenders and targets typically come together (Weisburd et al., 2012, p 40).

Just as, for a crime to occur, the offender must be motivated and the target suitable, so the place must be “facilitating” (Eck, 1994, p 29). There is substantial empirical evidence that the physical character of a place can influence the frequency of crime within it. Types of street lighting (Welsh and Farrington, 2008), modes of traffic calming (Matthews, 1997; Lockwood and Stillings, 1998), presence of trees and shrubs (Kuo and Sullivan, 2001), layout of the street network (Poyner, 1994; Johnson and Bowers, 2010; Tarkhanyan, 2015), construction materials used in buildings (Newman, 1980; Casteel and Peek-Asa, 2000) and many other features (see, for example, Felson et al., 1996; Clarke, 1997) have been shown to be associated with changes in the criminogenic nature of places.

The role of place in the routine-activities approach is somewhat anomalous because it is the only model element that is not a human actor. The mechanism by which places influence crime is therefore indirect, in that the nature of places influences the behaviour of the actors in the model, which in turn influences the frequency of crime. For example, through-streets (as opposed to cul-de-sacs) might have more potential offenders passing through, leading to more crime (Johnson and Bowers, 2010), while preventing access to alleyways behind houses might reduce crime by making it more difficult for offenders to access targets (Bowers et al., 2005).

One way in which the nature of places can influence crime is the use to which those places are put. Facilities are units within places that operate for a particular purpose, be it a school, business, church or apartment building (Eck and Weisburd, 1995, p 8). Although some facilities – such as a taxi company providing informal surveillance in a multi-storey car park (Poyner, 1997, p 158) – can be protective against crime, the majority of research attention to date has been directed at criminogenic facilities. Extensive research in this area (for recent reviews, see Wilcox and Eck, 2011, p 474, and McCord and Ratcliffe, 2009, pp 18–19) has shown that many types of non-residential land use are associated with higher crime. However, it is clear that within any category of facilities, a few “risky facilities” will account for most of the increase in crime (Eck et al., 2007) – Wilcox and Eck (2011, p 476) referred to this as the “iron law of troublesome places” because it has been so widely observed in relation to different types of facility. Recent research to understand the link between facilities and the places within which they sit has demonstrated a transfer of risk between facilities and their surroundings (Newton et al., 2014b) in which it appears that risky facilities “radiate” crime risk to the surrounding place (Bowers, 2014).

Place managers are individuals who “discourage crimes and reduce opportunities for criminal events through their presence and daily activities at specific places” (Mazerolle et al., 1998, p 372). In doing this their focus is on the place, rather than on the offender or target (Madensen, 2007, p 1). Research interest in place management has concentrated on those place managers who have legal or personal responsibility for a place, but place management may be exercised by anyone who is present in a place, such as visitors to a park or customers in a shop (Mazerolle et al., 1998, p 376). For some types of crime, the role of a place manager and a guardian will be very similar (Eck, 1994, p 28). However, even in such circumstances it is important

to analyse the roles separately because a person can be effective in one role while being ineffective in another. For example, a nightclub owner might go to some lengths to prevent the theft of equipment or drinks in their role as a guardian, but do very little to prevent drug dealing or thefts from customers in their role as a place manager (for an example of such a nightclub owner, see Eck and Eck, 2012, p 281).

Empirical studies have demonstrated that place managers can be effective in preventing crime. For example, improved place management has been found to be effective in preventing public disorder and on-street drug supply (Mazerolle et al., 1998), drug dealing in apartments (Eck and Wartell, 1998), fights in bars (Graham et al., 2004) and in apartment complexes (Eck et al., 2010), and on-street prostitution (Manning et al., 2014). However, research on place managers is not yet as developed as that covering other elements in the model such as guardians.

#### 2.6.4 *Super controllers*

Super controllers are people or organisations that create incentives for controllers to prevent crime (Sampson et al., 2010, p 40). They are second-order actors that do not manipulate criminal opportunities directly, but solely through their influence on controllers. Sampson et al. (2010, p 41) discussed three categories of super controller, but it is important to note that what matters is the role that a person plays, rather than their identity. As such, it may be more useful to consider the proposed categories in terms of the mechanism that allows them to act. The first, *formal* super-control, relies on defined authority to influence controllers, as in legislators enacting laws to compel or prohibit action by controllers or courts imposing fines on controllers who have failed to exercise control. *Diffuse* super-control works by using informal means to influence the incentives of controllers, operating at the level of the community or society rather than the individual. For example, a politician can influence social norms by engaging in public debate. Commonly, people can use market forces to influence controllers, for example by organising a campaign to boycott a product that facilitates a particular type of crime (Laycock, 2004). Finally, *personal* super-control involves people using interpersonal connections that are specific to their social network, such as a grandparent encouraging a father to discourage particular behaviour in his child.

These categories are not mutually exclusive. It is possible for a person to exercise super-control using multiple mechanisms, for example when a government passes a law requiring scrap-metal dealers to record the personal details of anyone selling scrap metal (formal super-control) and its ministers also make speeches and media appearances explaining why it is socially necessary that the controller should do that thing (diffuse super-control). A super controller may also fulfil other roles in the model. For example, a person taking part in a boycott of a criminogenic product may be exercising diffuse super-control, while at the same time reducing their own risk of victimisation.

As a relatively recent addition to the routine-activities approach, there is as-yet little empirical work on super controllers. Reynolds (2011) used the concept to identify potential actors who could influence website owners to reduce identity theft, while Klima (2011) found that a lack of action by super controllers had facilitated smuggling using the legitimate transport industry in Belgium. More recently, Payne (2015) found that schemes in which local governments threatened to fine the owners of places that generated high numbers of calls for police service were effective at reducing those calls by encouraging place managers to work with authorities to prevent crime. Similarly, Townsley et al. (2016) analysed the development and impact of super controllers on guardians, handlers and place managers responsible for preventing maritime piracy in the Arabian Sea and Gulf of Aden. They found that insurance companies and national governments had been able to reduce piracy by influencing controllers (for example by restructuring insurance premiums), but that some interventions had been more effective than others. Given the enormous breadth of potential super-controllers that could influence crime, however, the concept remains one that requires further exploration.

To summarise, the routine-activities approach provides a structured framework for the analysis of the different roles that can be played within a criminal event. Different forms of target guardianship, place management and offender handling can be important elements of crime scripts, as will be discussed in relation to metal theft in Chapter 6. First, however, it is necessary to understand some features of how the routine-activities model can be applied.

### 2.6.5 *Control mechanisms*

Until recently, little attention has been given to *how* controllers prevent crime. Smith (2014) demonstrated that the actions of controllers can be analysed using a typology of mechanisms from SCP. Initially proposed by Clarke (1980b) within the rational-choice perspective, SCP attempts to prevent crime by reducing or eliminating the “situational cues” to offending that potential offenders receive from their environment (Cornish and Clarke, 2003). It does this using

“opportunity-reducing measures that (1) are directed at highly specific forms of crime, (2) involve the management, design or manipulation of the immediate environment in as systematic and permanent way as possible” (Clarke, 1997, p 4).

SCP attempts to prevent crime by manipulating five factors in the decision-making process of an offender: the effort of offending, the risk, the rewards offenders are likely to obtain, the provocations for offending and the excuses offenders may tell themselves<sup>11</sup>. Table 2.3 gives examples of how these categories can be applied to understand the different ways in which controllers can prevent crime. Although the categories originate from SCP, their use to analyse the actions of controllers differs from the original concept in two ways. Firstly, instead of solely considering the offender’s decision-making process, controllers must also consider the decisions made by human targets or the owners of object targets. Secondly, although SCP focuses on changing the immediate environment that influences offending, measures taken by controllers are likely to be broader and will often not involve environmental change. For example, the prescription of drugs by a doctor (a handler) to prevent their patient from experiencing the euphoric effect of opioid abuse (Coviello et al., 2010) reduces the rewards experienced by offenders while doing nothing to change the environment.

Sampson et al. (2010) suggested using the same mechanisms to analyse the activities of super controllers. In this case the act that the super controller is trying to influence is not the crime itself but the actions of controllers to prevent crimes. For example, an insurance company (a super controller) might attempt to incentivise customers (guardians) to install burglar alarms

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<sup>11</sup> Like much of the theoretical framework discussed in this chapter, the mechanisms of SCP developed incrementally over time. These categories have been developed through the work of Hough et al. (1980), Clarke (1992), Clarke (1997), Wortley (2001) and Cornish and Clarke (2003).



Table 2.3: *Mechanisms of crime control for different controllers.*

This table is a version of that proposed by Cornish and Clarke (2003, p 90) – from which the technique names in *italics* are taken – reformulated to show how the techniques can be used by different types of controller.

Mechanism	Guardian	Place manager	Offender handler
Effort	<i>Screen exits</i> by attaching electronic tags to valuable goods (Farrington et al., 1993)	<i>Control tools/weapons</i> by bar staff serving drinks in toughened plastic containers instead of glass (Forsyth, 2008)	<i>Deflect offenders</i> by marshalling football fans before and after a match (Frosdick, 2005)
Risk	<i>Extend guardianship</i> using cocoon neighbourhood watch (Forrester et al., 1988)	<i>Assist natural surveillance</i> by cutting-back foliage (Atlas, 2013, p 629)	<i>Reduce anonymity</i> by requiring taxi drivers to display identification (Clarke, 1997, p 21)
Reward	<i>Deny benefits</i> by including dye packs in money given to bank robbers <sup>1</sup> (Carroll and Loch, 1997)	<i>Deny benefits</i> by using speed humps to make speeding unpleasant (Wallén Warner and Åberg, 2008)	<i>Deny benefits</i> by using opioid antagonist drugs to prevent euphoric effects of opiate use (Coviello et al., 2010)
Provocation	<i>Reduce frustrations and stress</i> by providing conflict-management training for staff at risk of assault (Henry and Ginn, 2002, p 483)	<i>Discourage imitation</i> by rapidly cleaning graffiti from railway carriages (Sloan-Howitt and Kelling, 1990)	<i>Avoid disputes</i> by offering intervention programmes to domestic abusers (Feder and Wilson, 2007)
Excuse	<i>Assist compliance</i> with crime-prevention measures through informal social control.	<i>Set rules</i> such as housing-tenant codes of conduct (Zehring, 1994)	<i>Alert conscience</i> by installing roadside vehicle-speed displays (Bloch, 1998)

<sup>1</sup> Dye packs may deny other benefits to offenders: Wroblewski and Smith (2008) reported the case of a bank robber who sustained serious burns to the groin when a dye pack exploded.

by offering them a discount on the home-insurance premium (Litton and Pease, 1984), thus increasing the rewards that customers can expect in return for their guardianship.

The use of the effort–risk–reward–provocation–excuse typology to analyse the actions of controllers and super controllers is at present under-developed, with no empirical tests of its usefulness. However, the examples provided in Table 2.3, as well as by Sampson et al. (2010) and Smith (2014), suggest that it has potential merit.

#### 2.6.6 *Convergence in space and time*

The central insight of the routine-activities approach at the micro level is that in order for a crime to occur, an offender and a target must come together in the same place at the same time<sup>12</sup>. The likelihood of their doing so depends partly on the characteristics of places, offenders, targets and controllers (as discussed above), but also on the “environmental backcloth” (Irving, 1977, p 876): “elements that surround and are part of an individual and that may be influenced by or influence his or her criminal behaviour” (Brantingham and Brantingham, 1993, p 6). The elements making up this backcloth are uncountably numerous, so a complete understanding is not possible (Brantingham and Brantingham, 1993, p 6). However, the effects of the backcloth on offenders can be studied, both at the individual and macro level.

The influence of the environmental backcloth on the convergence of offenders and targets can be understood using concepts borrowed from the field of human geography by Brantingham and Brantingham (1981). Gould (1975) showed how people’s awareness of their environment varied according to their exposure to it, with exposure being largely a product of a person’s movement through the environment. Over time, each person develops a unique “awareness space” (Brown and Moore, 1970, p 70): those areas about which they possess at-least some knowledge<sup>13</sup>. Since awareness space is developed through exposure, it is the product of a person’s routine activities: awareness space develops around the nodal locations of routine activities –

<sup>12</sup> The meaning of convergence, and of a place, will be different for crimes that occur online. However, since this thesis is concerned with offline offending, these issues will not be considered here.

<sup>13</sup> Since a person can generally only act within their awareness space, Wolpert (1965), Horton and Reynolds (1971) and others have preferred the term “action space”. However, awareness space is used here because it has become accepted within environmental criminology, although the two terms are broadly equivalent (Brown and Moore, 1970, p 70).

such as their home, workplace or preferred sites for shopping or leisure activities – and the paths that link those nodes (Brantingham and Brantingham, 1981).

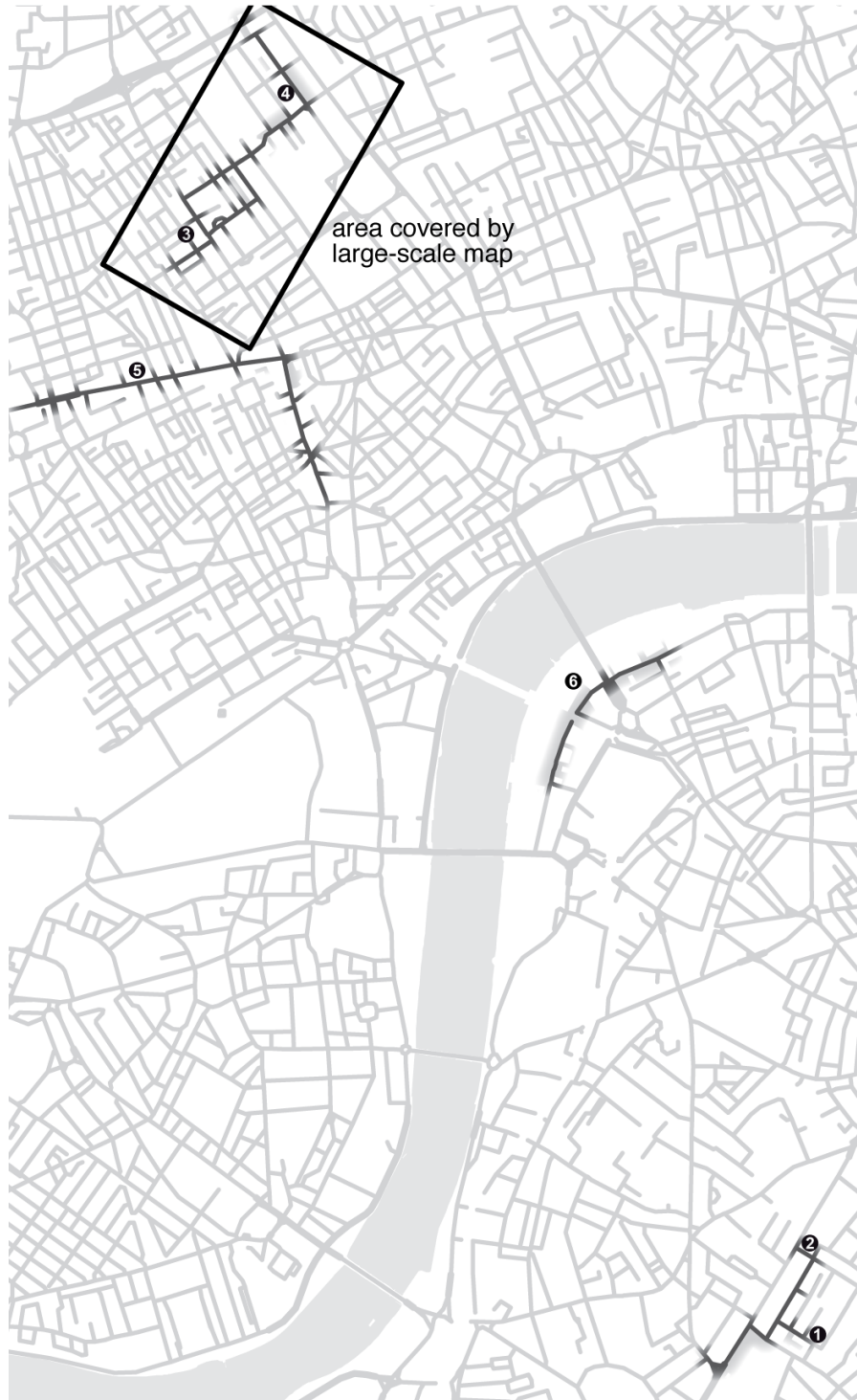
The limitations of a person's awareness space constrains their knowledge about their environment, including their knowledge about the availability of crime targets (Brantingham and Brantingham, 1981, p 238). At the most basic level, offenders will only be able to converge with targets that are within their awareness space because they will not know of the existence of those outside it. Figure 2.3 shows how the limitations of an offender's awareness space mean that he or she is more likely to converge with some targets than others.

Although each person's awareness space is unique (Palm, 1976), the environmental backcloth influences awareness in similar ways for different people, producing predictable aggregate awareness patterns (Gould, 1975). For example, a railway line may act as a physical barrier between neighbourhoods, limiting the awareness of one side among people who live on the other (Brantingham and Brantingham, 1993, p 18). By understanding the features of the backcloth that help shape awareness space, it is possible to make predictions about the frequency of crime in particular locations. For example, major roads are by their nature within the awareness spaces of many people, and so it might be expected that many offenders would be aware of any crime opportunities on or around those routes (Brantingham and Brantingham, 1981, p 252). Conversely, a quiet dead-end street nearby is likely to be within the awareness space of fewer offenders (unless it hosts a facility that attracts many potential offenders), and so may suffer from fewer offences even if there are many suitable targets present there.

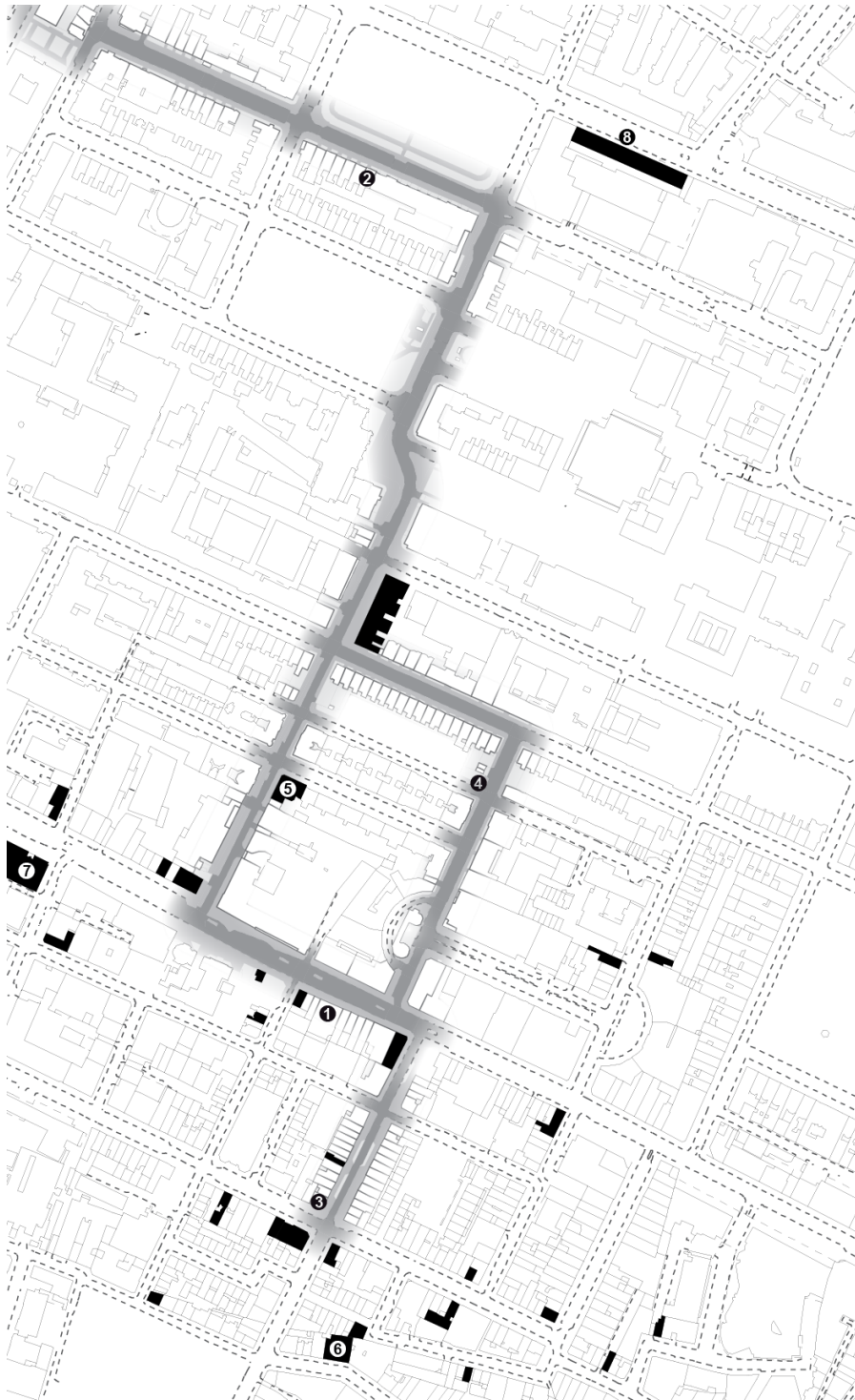
Although awareness space has been studied primarily in relation to offenders, the concept applies equally to the other actors in the routine-activities model. Just as offenders are more able to attack targets within their awareness space, so place managers will be more able to protect places that are within their awareness space. For example, university security guards who patrol in a vehicle are likely to have greater awareness of places close to the main routes through the university, and so be more able to protect them. Conversely, they may be less able to protect remote or obscure locations of which they are less aware, even though they have equal assigned responsibility for them. The effect of the environmental backcloth on crime is therefore mediated by the

Figure 2.3: *Offender awareness space*

- (a) A simplified representation of the author's awareness space in London (shaded) results from journeys from home (❶) via the nearest Underground station (❷) to another station (❸) and work (❹). Additional awareness space is generated by shopping (❺) and leisure activities (❻). Note that the above-ground awareness space appears not to be contiguous, because of the use of public transport, and that large areas of the city are outside the awareness space.



- (b) Part of the author's awareness space (shaded) results from journeys between an Underground station (❶) and workplace (❷), as well as trips to nearby shops (❸ and ❹). If the author wished to steal bags from local bars or cafés (highlighted in black), he is likely to do so in places (such as ❺) that are within his awareness space rather than those (such as ❻, ❼ and ❸) of which he is not readily aware.



overlapping awareness spaces of all the actors in the model, as well as by the uneven spatial distribution of targets.

#### 2.6.7 *Using the routine-activities approach to prevent crime opportunities*

Although originally formulated as an explanation for long-term changes in the frequency of crime in society, the routine-activities approach has often been used to allow the identification of ways to prevent crime opportunities. The formulation of the approach as the crime triangle (Figure 2.2) borrows logic from the fire triangle commonly used by fire engineers. This conceptualises fire as being the result of the convergence of fuel, oxygen and a source of energy for ignition, the removal of any one of which will either prevent a fire igniting or cause it to be extinguished (Quintiere, 1998, p 24). In the case of the crime triangle, any modification that prevents a motivated offender and a suitable target from coming together in a facilitating place will prevent the crime from occurring (Buerger, 1994, p 3; Sherman, 1995, p 38).

The value of the crime triangle as an analytical tool for crime prevention is that it ensures that the victim and place will be considered as potential foci for crime prevention (Clarke and Eck, 2003): otherwise, as Sherman (1995, p 38) argued, “motivated offenders . . . get most of the blame for crime, just as heat gets much of the credit for fire”. By considering all elements of a criminal opportunity, it is possible to identify which element can most-efficiently – i.e. easily and effectively – be modified so as to prevent the crime from occurring (Clarke and Eck, 2003). In many cases the most-efficient element on which to focus will not be the offender, since it is often very difficult to change the long-term personal and social factors that might influence an offender’s motivation (Wilson, 1975, p 52; Clarke, 1980b, p 137). Instead it is often (although not always) likely to be more productive to focus on either the target, the place or a combination of both.

Place- and target-focused crime-prevention initiatives have shown considerable success in reducing crime (for reviews, see Eck, 2002; Cozens et al., 2005; Guerette and Bowers, 2009). However, these successes depend upon being able to identify efficient ways to modify a crime opportunity. This, in turn, is likely to depend upon problem-specific analysis of the crime that the analyst is trying to prevent (Eck and Spelman, 1987, p 53) – something that crime-prevention initiatives often lack (Scott, 2000, p 141). As will be shown in Chapters 7 and 9, lack of analysis has been a feature of some parts of the

response to the problem of metal theft from the railway network, something that this thesis will attempt to help remedy.

Before applying the theoretical frameworks outlined in this chapter to the problem of metal theft from the railway network, the Chapter 3 will explain that problem in more detail, before existing work in the field is considered in Chapter 4.







## THE PROBLEM OF METAL THEFT

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### SUMMARY

- Metals are widely used in society and so metal thefts have occurred historically, but in low numbers.
- In recent years the number of metal thefts has increased substantially, driven partly by the increasing prices of many non-ferrous metals.
- Metal can be stolen from many sources, including domestic settings and historic buildings but particularly from infrastructure networks.
- Metal theft from railway networks is important because it causes widespread disruption, because those networks typically have low redundancy and because delays to trains can propagate quickly over large distances.

### 3.1 INTRODUCTION

Metal theft is not a new phenomenon. Bennett (2008, p 179) gave examples of thieves in the 19th Century who specialised in stealing copper from ships in London, while Posick et al. (2012, p 81) noted that metal thefts occurred in the US during the same period. Nevertheless, it appears that for most of history metal thefts have been infrequent enough to be regarded as a tolerable nuisance rather than a substantial threat. Taylor et al. (2003) relayed an anecdotal report that, although theft of cable was a long-standing problem for electricity companies, theft of goods from storage and illegal diversion of electricity were considered to be more important issues, such that metal theft received little attention. Bompard et al. (2013, p 62) estimated that malicious threats to power networks were far less common than threats from natural hazards (such as trees falling on power cables) or accidents (such as construction vehicles hitting overhead lines).

Although many countries do not record metal thefts separately from other thefts, the problem does appear to have become much more common in recent years. A survey by the Local Government Association (2013, p 8) found that 90% of local-government districts in England and Wales have suffered metal thefts, while the American Association of State Highway and Transportation Officials (2013) found 34 out of 50 US states had experienced copper theft from highway infrastructure. Also in the United States, Caltrans (2013, p 1) reported so much metal theft from roads in California that maintenance staff were unable to replace metal as quickly as it was being stolen.

This rapid increase in offences has led to some hyperbole: the Institute of Scrap Recycling Industries (2008) claimed that “materials theft has become an overwhelming problem around the world”, while Maag (2008) wrote

that “our neighborhoods are being pillaged, not by Vikings or Goths, but by modern-day barbarians”. The pendulum of concern may thus have swung too far the other way: more than 99% of US electricity utilities surveyed by the Electrical Safety Foundation International (2009) said they were concerned about copper theft, but none of the major US electricity-supply companies mentioned losses from metal theft in their 2008 or 2009 annual accounts (Rout et al., 2010, p 4).

### 3.2 WHY HAS THE PROBLEM ARISEN?

The quantity of metals available for purchase worldwide is equal to the amount of metal mined (primary production) plus the amount recycled (secondary production) from previous uses (Dottori et al., 2011, p 17), but both of these sources are problematic. The quality of ore available for mining is declining over time (Prior et al., 2012, p 579), which increases the cost of extracting it (Adelman, 1990, p 3). Mining also has substantial environmental impacts – producing one tonne of copper from ore creates 200 tonnes of waste (Spoel, 1990, p 38) – and environmental concerns sometimes prevent the opening of new mines (Prior et al., 2012, p 581). The potential depletion of ore reserves raises the potential of “peak minerals” (May et al., 2012), after which primary metal production will decrease due to the scarcity of ore. Mudd and Ward (2008, p 4) argued that this may already have occurred in some countries.

Recycling metal avoids these problems. It is also less energy intensive – and therefore less expensive (Medina, 2001, p 237; Fletcher, 1976, p 151) – than mining (Frosch et al., 1997, p 1339). However, the availability of metal for recycling is limited by the long lifespan of many manufactured goods that contain metal: Ayres et al. (2002, p 40) found that copper products have a typical lifespan of 33 years. Some uses of metal in products – such as copper in paint – also preclude recycling, further limiting the availability of metal from secondary sources (Lifset et al., 2002, p 25).

Theft of metal artificially shortens the metal life-cycle and increases available metal stocks, so a shortage of available metals could make theft more attractive. This is likely to be particularly true in the period immediately after a spike in prices, because there are substantial lead times for opening new mines or re-opening closed ones in response to increased demand.

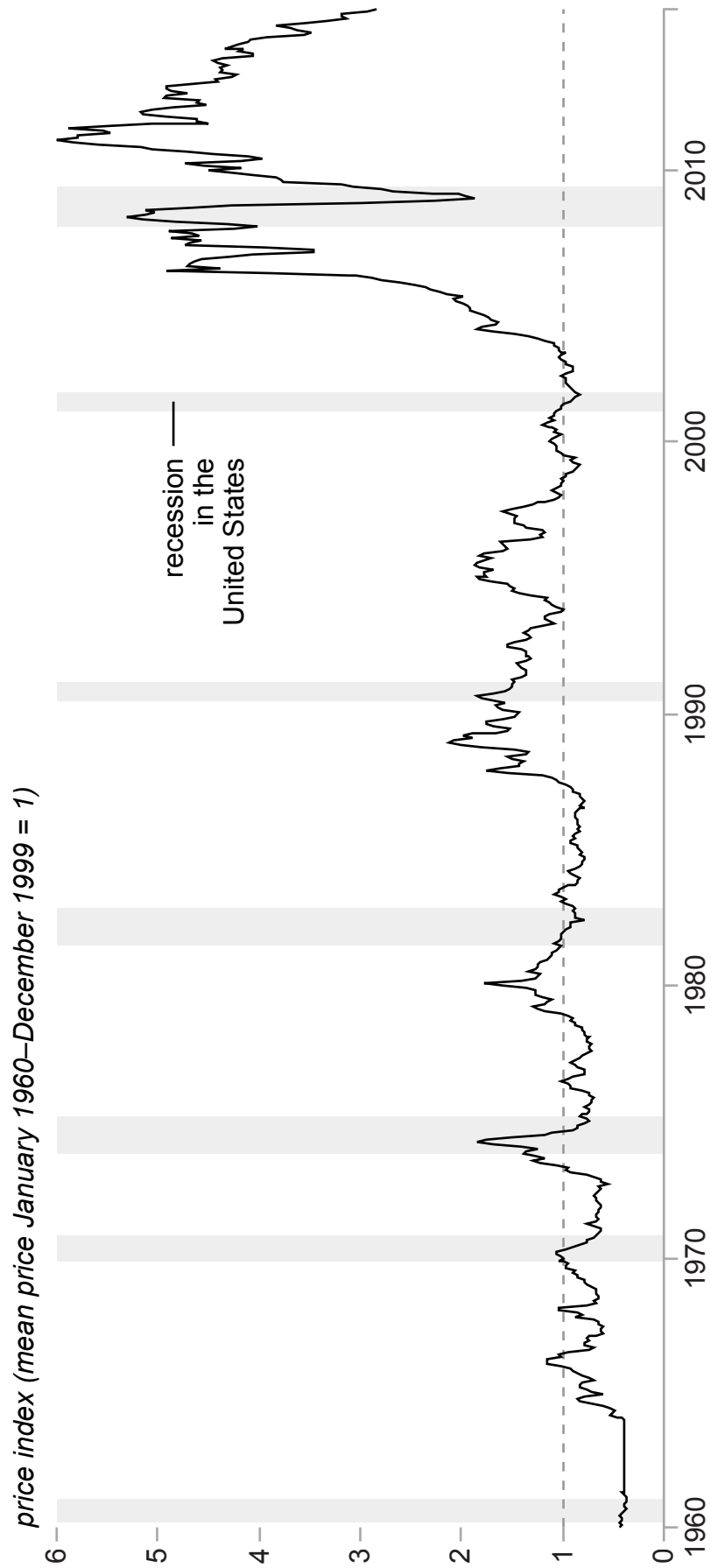
Bennett (2008, p 178) argued that increased demand for metals for infrastructure projects (for example in China and India) has disrupted the previous cyclical nature of metal prices and led to the longest price boom since the Second World War, seeming to “ignite a problem that had been simmering for decades” (Electrical Safety Foundation International, 2009). In 2011, China consumed 40% of world copper production (CRU Strategies, 2013, p 36), while in 2013 the United Kingdom (UK) exported scrap copper with a value of £31 million to China every month – 82% of all scrap copper exports (HM Revenue and Customs, 2014). Dottori et al. (2011, p 19) found a common belief among institutional metal-theft victims that thefts were at least partly driven by the price of metals. Sidebottom et al. (2011, 2014) provided evidence to support this hypothesis when they found a covariation between the wholesale price of copper and the monthly frequency of metal theft on the UK railway network. However, data were not available on the amount of copper stolen, so it was not possible to establish whether the amount stolen varied in line with price changes (although this may be a fine distinction in practice).

Data on the changing price of copper are shown in Figure 3.1. This shows a substantial increase in prices since 2005, compared to historical averages over the previous 40 years. Although there was a decrease in prices after the 2008 financial crisis, even then prices did not return to their historical averages and in any case rebounded quickly so that by the end of 2015 the price of copper, for example, remained three-times higher in real terms than between 1960 and 2000.

### 3.3 METAL AS A VULNERABLE TARGET FOR THEFT

Metal has a huge variety of applications in society, from the cables of suspension bridges to the circuits in digital watches. Although any type of metal could (and perhaps occasionally will) be stolen, some types of metal are likely to be more vulnerable to theft than others. Clarke (1999) suggested that items are likely to be more attractive to thieves if they are easier to steal, particularly if they are CRAVED (see Section 2.6.2). Many types of metal do not have these characteristics – Pease (1997, p 235) reported that 19th Century miners in California cast silver into 200 kilogram blocks to make them difficult to steal – but many do. Consideration of the CRAVED

Figure 3.1: *Changes in the wholesale price of copper, 1960–2015.*  
Source: World Bank (2016)



characteristics in relation to metal suggests that metal might be stolen more often if it has particular features.

**CONCEALABILITY** Wellsmith and Burrell (2005, p 753) found that thieves prefer to steal goods that can be concealed in a hold-all bag. However, it being possible to physically hide an item from sight is only one way in which it can be concealable: what matters is that it should not be identified as being stolen. While thieves may prefer small items, those who are able to appear to have innocent possession of larger items may be able to successfully steal them in plain sight. Such thefts have been reported in the media (e.g. Whalen, 2011; Schwartz, 2014), with thieves having used fake utility-company uniforms to allow them to carry off metal items too large to remove surreptitiously. However, not all thieves will have such capability, and it therefore might be expected that thieves will prefer items that are small enough to carry (such as brass plaques), or that can be cut up into small pieces (such as copper cable).

**REMOVABILITY** In order to steal an item, a thief must(a) remove it from its legitimate location within the time available, (b) use only the tools available and (c) avoid apprehension. In the case of many metal items (such as telephone or power cable), removability is complicated because the item often forms part of a system that is electronically monitored for faults. Removing an item will cause a fault that the system operator is likely to investigate. As such, thieves may have a preference for items that are not monitored. This may explain some thieves' apparent preference for electrical earthing cable (Narayan and Regan, 2013), which cannot be electrically monitored because any current passed through it is (by design) conducted to earth. Some types of metal – such as copper piping in a house – may be removable only with some physical effort and at the expense of damage to surrounding walls, as well as the risk of water leakage or even gas explosion (Bennett, 2008, p 178). This may explain why those stealing pipes appear to target abandoned buildings (Posick et al., 2012, p 93), in which they are less likely to be disturbed by the owners.

**AVAILABILITY** In order to be stolen, a product must be available at three levels (Clarke, 2000, p 255): it must exist (*macro* availability), it must be available in same neighbourhood as a potential thief (*meso* availability) and

the thief must know of the item and be able to physically access it (*micro* availability)<sup>1</sup>. The wide use of metal in society gives it high accessibility at the *macro* and *meso* levels. *Micro* availability is often high as well, partly because almost all the metal in infrastructure networks was installed before metal theft became a crime problem, and so little thought was given to protecting it from theft. Metal is often used in remote locations such as the roofs of buildings or alongside remote rural lines, where guardianship is low and there is little to stop thieves from stealing it unseen (see Section 3.7).

**VALUE** As discussed in Section 3.2, various types of metal have become more valuable in recent years. Even though thieves are often able to sell stolen goods for only a fraction of their true value (Wellsmith and Burrell, 2005, p 754), it appears that what value thieves can get from stolen metal is now sufficient to make metal a CRAVED item when the other required characteristics are present.

Figure 3.2 shows the frequency of live-metal thefts from the railway network between 2007 and 2012, overlaid with the international wholesale price of copper on the London Metal Exchange during that period. The number of thefts each month appears to be volatile, with between 20 and 131 offences occurring. There have been two peaks in metal theft, extending from early 2007 to late 2008 and then from early 2010 to late 2011. These peaks were each followed by sharp decreases in the frequency of thefts, such that by the end of 2012 there were fewer offences than at any time in the previous six years.

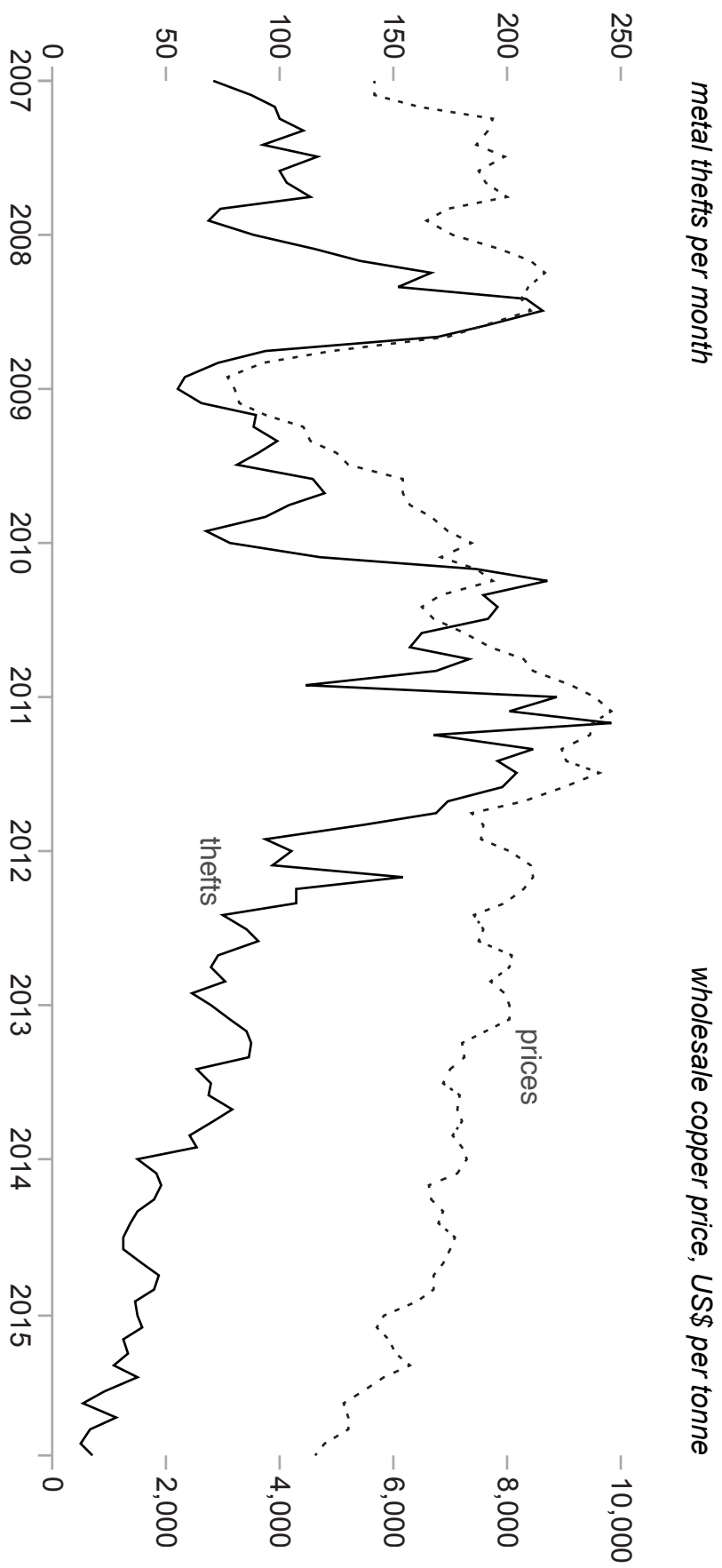
Sidebottom et al. (2011) discussed the close correlation between the incidence of theft and the price of copper, concluding that thefts are at least partly driven by the changing value of copper. Figure 3.2 shows that this relationship appears to have broken down during 2012, when the price of copper remained steady but the number of thefts dropped sharply. This may be due to the introduction of a factor not previously present, such as increased targeted policing or better physical security (p see Sidebottom et al., 2014, for further discussion).

**ENJOYABILITY** While metal is not as obviously enjoyable to thieves as (for example) stolen alcohol (Trembl, 1982, p 494), drugs (Inciardi et al., 2007,

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<sup>1</sup> Pires and Clarke (2012, p 139) suggested disaggregating the concept of availability into abundance and accessibility, but these concepts appear to be captured by the notions of *meso* and *micro* availability.

Figure 3.2: *Long-term variation in theft of metal from the British railway network, 2007–15.*  
 Sources: British Transport Police, World Bank (2016)





p 178) or guns (Kennedy et al., 1996, p 147), it can be quickly and easily converted into cash, which in turn can be used to purchase other enjoyable things. The enjoyability of metal therefore depends upon thieves being able to sell it. This suggests a key role for handlers of stolen metal, which will be discussed further in Chapter 8.

**DISPOSABILITY** A successful thief must(a) dispose of the goods without being apprehended, (b) get a reasonable return for their investment of time and risk, and (c) do this quickly. Since retaining stolen goods increases the risk of apprehension, thieves of various types commonly sell goods within hours (Stevenson, 2001, p 112) or even minutes (Sutton, 2008, p 41) of the theft. Although the strong demand for metal means thieves are likely to be able to find a ready market for stolen metal, the need to dispose of items quickly may constrain the locations to which they can take stolen goods. This may lead to concentrations of thefts in areas where it is easier to sell stolen metal, a possibility discussed further in Chapter 8.

Overall, it appears that many metal items fit the CRAVED criteria well, and that the CRAVED nature of metal items may allow prediction of some features of the problem of metal theft.

### 3.4 TYPES OF METAL THEFT

There is no accepted typology of metal theft, and the term has been used for several quite-different crimes. The following categories are suggestions based on the sources cited.

1. *Infrastructure-metal theft*. Thefts of metals used in infrastructure, for example rails from railways (Milmo, 2008), telephone cable from communications utilities (McCorkell, 2011), conductive cable from electricity substations (Cooke, 2010) and drain covers from roads (Aslet, 2008). These thefts are particularly concerning because they can cause substantial disruption to the public (Wright, 2011) and can endanger people's safety (Hamilton and Simpson, 2011; Local Government Association, 2012).
2. *Architectural-metal theft*. This includes lead sheets from church roofs (Hollingshead, 2011), bronze sculptures from public places (Bannerman, 2011) and plaques from war memorials (Edgar, 2012). These thefts often

cause particular distress to victims because the items in question may be of emotional or historical value and cannot be replaced.

3. *Domestic- and business-metal theft.* This ranges from the theft of agricultural machinery from farms (Ruscoe, 2008) to beer kegs from breweries (Edemariam, 2008), as well as the theft of miscellaneous metal items when individual opportunities present themselves. The harms caused by these incidents vary enormously.

Metal theft can also be categorised by the material stolen. Posick et al. (2012) noted that ferrous metals can be stolen – such as the theft of iron railings from outside buildings (Milmo, 2008) – but most thefts appear to be of non-ferrous material. Kooi (2010) described aluminium, copper, nickel and zinc as being particularly vulnerable to theft. Of these, Posick et al. (2012) stated that “copper is by far the most common metal stolen”.

### 3.5 THE COSTS OF METAL THEFT

It is perhaps surprising that metal theft was seen by many infrastructure providers as a low-priority issue, because the theft of even a small amount of metal can have substantial second-order consequences. The impact reported by Brathwaite et al. (2013, p 6) appears to be typical of many areas:

“citizens have experienced disruptions to rail services, interruptions to telecommunications, theft of lead and copper from the roofs of churches, schools, private and council buildings, the theft of street signs, gully and manhole covers, and, most reprehensible, theft from war and grave memorials.”

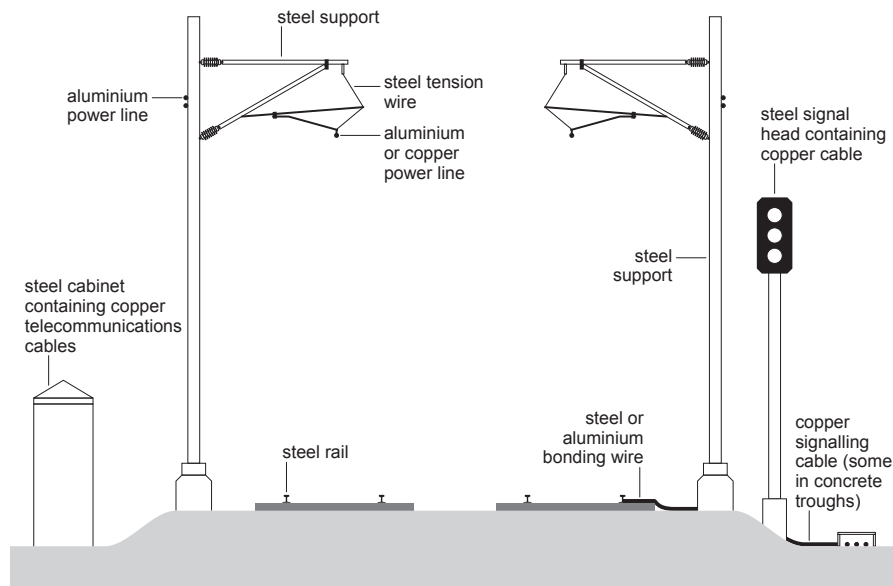
Metal thefts can have substantial consequences for victims and others in society, even if the value of the metal stolen is small. For example, several recent thefts of small amounts of electrical cable from hospitals have led to the cancellation of cancer screening and even urgent surgery (Stone, 2011; Collins, 2011).

### 3.6 METAL THEFT FROM THE RAILWAY NETWORK

The particular focus of this thesis is metal theft from the UK railway network, for reasons discussed in Chapter 5. Figure 3.3 shows types of metal that are typically present on railway lines and which are vulnerable to theft.

Figure 3.3: *Metal vulnerable to theft on a typical railway line.*

For more details, see Goldring and Suddards (1971); Glover (2013).



Robb et al. (2014) described several types of metal theft that occur on the UK railway network, including offences that fall into all three of the categories listed above. The most concerning are thefts of metal used in infrastructure, which typically involves the theft of copper signalling or telecommunications cable from the track-side, theft of steel or aluminium rails, and thefts of cable from electrical sub-stations. Given the age of the railway network in Britain, it is also vulnerable to architectural-metal theft, such as when lead sheets are stolen from station roofs, and business-metal theft. The latter takes many forms, such as theft of metal signs, fixtures, fences and redundant metal left in-situ (Robb et al., 2014). The variety of metal that can be stolen from the railway network makes it a useful focus for the study of metal theft, particularly given that good-quality data are available on metal theft from railways in Britain.

### 3.7 THE VULNERABILITY OF THE RAILWAY NETWORK

Studying metal theft on railways is important because the railway network is especially vulnerable, both in that it is particularly likely to become a target

of metal theft and that the consequences of such victimisation are likely to be particularly severe.

The design of many railway networks presents a large number of opportunities for theft. The need to control the movement of trains and for staff to communicate over long distances means that running alongside almost every railway line are multiple signalling and telecommunications cables (Figure 3.4). Although newly installed cables transmit signals via optical fibres, railway cable has a very long life-cycle: there are signalling cables currently in use on some London Underground lines that were installed in the 1920s (Pank, 2010, p 13). As such, there are likely to be large volumes of metal at the side of most railway lines for several decades to come.

Common protective factors against theft are often absent on railways. Guardianship is low: tracks pass through fields or between the backs of houses, where there is unlikely to be anyone who might observe a theft occurring. Target hardening, meanwhile, is often rudimentary: although railway operators are legally required to prevent unauthorised access to tracks<sup>2</sup>, in rural areas the only boundary is typically a low fence, which is often interrupted by foot or vehicle crossings (Figure 3.6).

Once a theft has occurred on a railway line, the consequences are likely to be more severe than if a similar quantity of metal had been stolen in a business or residential setting. The large electrical current flowing through many railway cables means thieves often run the risk of electrocution (see Section 4.4). More commonly, thefts of railway cable cause substantial delays to train services and the passengers using them. This potential for widespread disruption to passengers is the reason why metal theft from railway networks is an important crime worthy of attention from both academics and practitioners. The railway network is particularly vulnerable to disruption because of two features of the system: the potential for secondary delays to propagate quickly and low levels of redundancy that hamper service recovery.

### 3.7.1 *Primary and secondary delays*

Delays to trains can be categorised as primary, caused by some external factor that prevents a train from proceeding, and secondary, caused by a delayed train preventing other trains from operating on time (Al Ibrahim,

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<sup>2</sup> See paragraph 3 of the Railway Safety (Miscellaneous Provisions) Regulations 1997.

Figure 3.4: *Track-side cables*  
Images: the author

- (a) Cables on a mainline railway are inside the concrete trough on the right, the lids of which are usually not secured.



- (b) Cables on London Underground run along the side of the track on racks.

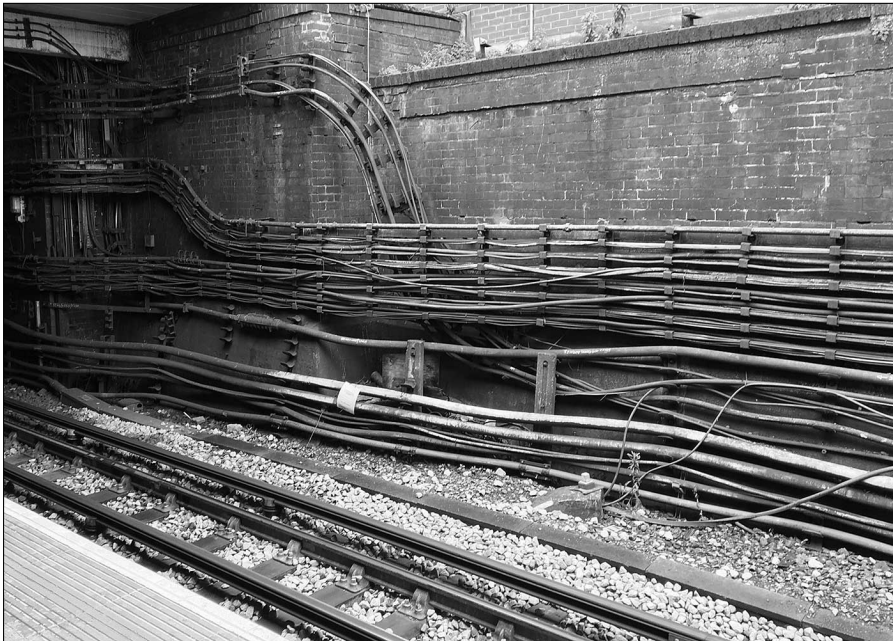


Figure 3.6: *Physical security on railway networks.*  
Images: the author

(a) Many railway fences can be easily climbed over.



(b) In rural areas, foot crossings provide easy access to, as well as across, railway tracks.



(c) Vehicle crossings also provide access to the tracks.



(d) Long stretches of railway line make place management difficult, meaning weaknesses such as this hole cut in a fence may go un-noticed for long periods.



2010, p 5). Metal theft is one of many causes of primary delays, which are also commonly the result of obstructions on the line, signal failures, defective trains, poor weather and so on (Pender et al., 2013, p 26). Primary delays can be substantial, but secondary delays are likely to be larger because of the high degree of dependency between train services (Vromans, 2005, p 35). For example, a train cannot begin its journey if the allocated rolling stock has been delayed on a previous journey and has not arrived, or if the crew is onboard a previous, delayed service. Similarly a train cannot call at or pass through a station as planned if the relevant platform is occupied by a delayed train.

Higher-order delays are likely to be particularly severe if the network is heavily used (Vromans, 2005, p 35). The UK has the second-busiest railway network in the European Union (EU) (Eurostat, 2011), with 1.35 billion journeys each year (Office of Rail Regulation, 2012). A mean of 94 trains pass any given point on the National Rail<sup>3</sup> network each day (the highest in any large European country – Eurostat, 2011), such that if a train stops unexpectedly for any reason there will be only a little time before the following train is also delayed. Half of railway journeys in Britain are for business or commuting purposes (Department for Transport, 2011, Table TSGB0104), so the potential for secondary delays is often highest during rush hour.

These factors combine to mean that even a small incident can cause very large delays. For example, in the busiest three hours each morning, more than 150,000 passengers pass through Clapham Junction station in London (Network Rail, 2011, p 55). An early-morning cable theft that caused a failure of signalling in that area could cause primary delays to all of those passengers, along with secondary delays due to displacement of rolling stock and train crew as well as disruption to services obstructed by trains suffering primary delays. The secondary delays would be likely to propagate far beyond London, particularly because trains queueing to pass through the blocked area could obstruct freight and cross-country passenger services many miles from the capital. These services would then cause knock-on disruption as they proceeded on their (delayed) journeys across the country. As such, an incident in one part of the country can cause secondary delays several hundred kilometres away several hours later. In one incident near Doncaster, thieves stole railway cables that they later sold for £4,000

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<sup>3</sup> The National Rail network includes all non-heritage trains in Great Britain except for the Docklands Light Railway, London Underground, Glasgow Subway and Tyne and Wear Metro networks.



but caused disruption that resulted in Network Rail (the publicly owned company that operates the railway network in Great Britain) having to pay £250,000 in compensation to train operators (Burn, 2016).

### 3.7.2 *Low redundancy*

As well as being particularly vulnerable to secondary disruption, the railway network is unusually ill-equipped to recover when compared to other infrastructure networks. High-voltage power and trunk telephone networks, for example, typically have many redundant paths that allow un-interrupted service in the event of a failure (Zorpette, 1989; Harris, 2006). In a railway network, there is often only one route between any two cities, such that an obstruction at any point on that route is likely to represent a single point of failure with respect to service between those destinations. Even where there are multiple routes between two cities, different signalling systems and rolling-stock requirements (as well as the safety requirement for train drivers to have recent knowledge of the route they are working on) mean that trains can only make a diversion with weeks or even months of planning. In the event of unexpected disruption (such as that caused by metal theft) there may be little option but for trains and their passengers to wait until the service is restored. The limited scope for mitigating action when disruption occurs means that post-incident delays on railways are likely to be greater than they would be on (for example) the road network. For example, a cable theft outside London during the evening peak period disrupted journeys for approximately 80,000 commuters, few of whom would have had any alternative route home (South West Trains, 2011).

## 3.8 THE IMPORTANCE OF STUDYING RAILWAY METAL THEFT

There are many crimes that are more common than metal theft from the railway network. In 2011–12, for example, there were 2,526 recorded metal thefts from railways in England and Wales, compared to 14,570 thefts from railway passengers (British Transport Police, 2012, pp 10–18). What makes metal theft an important topic for study is the disruption it causes to passengers and freight, and the very-high associated costs. During 2011, for example, Network Rail paid more than £10.2 million to train operating companies for

delays relating to metal theft (Ashby, 2012, p 5). This figure does not include the cost of equipment or labour to replace stolen metal.

The next chapter will discuss previous research on the topic of metal theft. Chapter 6 will then analyse the problem of railway metal theft in more detail, in order to identify potential opportunities to assist practitioners in their efforts to understand and prevent it from occurring.





## PREVIOUS RESEARCH ON METAL THEFT

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### SUMMARY

- As a recently emerged crime problem, there is only limited published research on metal theft.
- Copper is frequently stolen because it is widely used and so is both frequently available for theft and in constant demand.
- Limited evidence suggests that metal theft may exhibit different features from other types of acquisitive crime.
- Scrap-metal dealers are often described as being involved in metal theft, but evidence is limited.
- It is commonly suggested that organised-crime groups are involved in metal theft, but there is little evidence to support this.



#### 4.1 INTRODUCTION

The problem of metal theft has only recently caught the attention of academics and practitioners. As such, there is comparatively little research on different aspects of the problem, and what literature exists has concentrated on answering only a few research questions. This is beginning to change as researchers address the questions that policy makers and practitioners ask in their attempts to prevent thefts from occurring. However, the pace of academic research has proved too slow to meet the needs of practitioners who have come under public and political pressure to reduce the number of thefts and their impact. In the absence of academic studies, policy makers have turned to other sources of evidence to inform their decisions<sup>1</sup>.

Consistent with the routine-activities approach outlined in Section 2.6, the following review of existing literature is arranged according to the different elements that make up a crime event. This structure allows the identification of gaps in the existing literature, some of which form the basis of empirical work presented in subsequent chapters.

#### 4.2 METAL-THEFT TARGETS

Empirical evidence on the vulnerability of different types of metal is scarce, with only a few studies mentioning it and such mentions being incidental. Posick et al. (2012, p 93) found that burglaries in which metal was stolen

<sup>1</sup> This review does not cite a number of articles related to metal theft that were published in “predatory” open-access journals (Beall, 2012, p 179), i.e. journals which will publish almost any article (however flawed) without peer review in return for a publication fee (Bohannon, 2013). Articles in such journals are not cited here because the lack of peer review means there is little protection against them containing results based on poor data, inappropriate methods or author misconduct (Beall, 2013). For more information (and a list of known predatory journals) visit [scholarlyoa.com](http://scholarlyoa.com)

were disproportionately concentrated in abandoned buildings, compared to burglaries in which metal was not stolen. Kooi (2010, p 5) suggested that this might be because burglars targeted the copper piping and other metal fixtures that are often present (unguarded) in abandoned houses. Grove (2013, p 245) noted that in the UK churches were frequent targets of metal theft and suggested that this may be because many have lead roofs and because they are unoccupied much of the time.

Dottori et al. (2011, p 23) suggested that railway copper may be particularly valued because of its high quality, although they offered no evidence for this. Robb et al. (2014) identified several types of metal theft from railway networks, based on analysis of 4,000 metal thefts recorded by British Transport Police (BTP) in 2009–10. The most common target was line-side cable, followed by cable stored in depots and thefts of miscellaneous metal items such as signs and roofing. Sidebottom et al. (2011) found that the proportion of thefts that were from railway depots decreased over time, and suggested that this may be due to increased awareness of the problem of metal theft among railway staff.

Taylor et al. (2003) noted that offenders stealing from electrical substations could not visually distinguish between live cables carrying lethal currents and neutral lines. However, Electrical Safety Foundation International (2009) found that 85% of thefts of metal from electrical infrastructure involved non-energised equipment. This may suggest that offenders who target substations do so with some prior knowledge of what metals to target.

#### 4.2.1 *Forensic identification of stolen metal*

Several studies have attempted to apply forensic techniques to the problem of metal theft. Both Bond et al. (2013) and Dettman et al. (2014) used analysis of the constituent chemicals in samples of stolen metal to demonstrate whether or not they came from a particular batch of the original metal product. In this way, stolen metal recovered by the police could be linked to a specific crime by matching the recovered metal to metal from the same site that had not been stolen. If widely deployed, this technique could make prosecutions easier in cases where police find a person with metal that they believe has been stolen, but at present are unable to charge the person with any offences because they cannot prove from where the metal was taken. However, the

long life-cycle of metal (Section 3.7) means large-scale deployment of tracing technology may take time.

Other studies have considered the opposite problem: if a person is found close to the scene of a metal theft, how can they be linked to the crime if they do not have any metal in their possession when stopped. Wightman et al. (2015) considered methods for identifying and preserving fingerprints on metal items, particularly if the metal is corroded, has been burnt or exposed to water. In the absence of fingerprints, Bleay et al. (2014) developed a technique to detect microscopic metal particles on the hands of thieves.

#### 4.3 PLACES WHERE METAL THEFT OCCURS

There is very little available information on the spatial or temporal distribution of metal theft. Except for a few descriptions of local hotspots (e.g. House of Commons Transport Committee, 2012, p 7), the only published works on spatial clustering of metal thefts appears to come from two studies of cities in the US.

At the state level, the American Association of State Highway and Transportation Officials (2013, p 6) found that metal thefts from highway infrastructure were concentrated in a few states. However, this finding resulted from a voluntary survey of state highway authorities, and so it is possible that the authorities responding to the survey had an incomplete picture of thefts in their state. Also, a study at such a high level of spatial aggregation is almost certain to conceal substantial variation within states, and so the results should be treated with caution.

Posick et al. (2012, p 92) found that burglaries involving metal theft in the city of Rochester, New York, were less clustered than other burglaries. However, anecdotal evidence suggests that thieves operate across administrative boundaries (Local Government Association, 2013, p 17; Brathwaite et al., 2013, p 3), so any spatio-temporal analysis would benefit from data from several agencies or a national agency.

Rout et al. (2010, p 7) and Brathwaite et al. (2013, p 12) suggested that the geographical distribution of metal thefts may be associated with the availability of scrap-metal dealers (SMDs) willing to accept stolen metal, but offered no evidence that that was the case. The only available evidence of such a link is that Whiteacre and Howes (2009) found a positive relationship between the number of scrap-metal dealers in a city and the amount of



reported metal theft. However, there were several methodological issues with this study (as will be discussed further in Chapter 8).

#### 4.3.1 *What we don't know about metal-theft places*

With only two extant studies, many aspects of the spatial and temporal distribution of metal theft remain unknown. Although evidence suggests that metal thefts are spatially clustered, there is no evidence as to the type of areas in which clusters occur or what features of the environment might lead clusters to form. As far as the author is aware, there is no existing published evidence on the temporal distribution of metal theft. This leaves open questions such as whether metal theft exhibits the periods of elevated risk of repeat and near-repeat victimisation seen in other crimes, or whether the locations of spatial clusters are stable or vary over time. Filling these research gaps would have two benefits: the results would be useful to practitioners attempting to combat metal theft, and would allow testing of the generalisability of existing findings on spatial and temporal clustering of crime generated from studies on other types of crime.

Evidence of a link between the locations of metal thefts and the local availability of SMDs would be valuable because discussions between the author and practitioners suggest that many believe that a market reduction approach (MRA) (Sutton, 1998) targeting SMDs would reduce metal theft. However, existing evidence for MRA is limited (Hale et al., 2004), making empirical research into this question particularly relevant.

## 4.4 METAL THEFT OFFENDERS

Very little is known about people who steal metal. Taylor et al. (2003) studied eight individuals killed while attempting to steal electrical cable in one US county between 1981 and 2001. All were men between 17 and 55 years' old. Gorse et al. (2013) reported that all six patients who were burned while attempting to steal cable in Wales between 2007 and 2012 were men, and that their median age was 30 years, similar to the mean age of 27 years reported by Curinga et al. (2010, p 343). Electrical Safety Foundation International (2009) estimated that in the United States 35 people had been killed and another 52 injured during 2009 during 50,200 copper thefts from electricity substations. Thieves who survive electric shocks often suffer very serious

injuries (Baker et al., 2008; Dunne et al., 2015): 60% of the metal thieves treated in one Italian burns unit required at least one surgical amputation (Curinga et al., 2010, p 343).

Several sources have suggested that organised crime groups (OCGs) might be involved in metal theft, but evidence for such an assertion is scant. The Federal Bureau of Investigation (2008) claimed that

“Copper thieves are typically individuals or organized groups who operate independently or in loose association with each other and commit thefts in conjunction with fencing activities and the sale of contraband. Organized groups of drug addicts, gang members, and metal thieves are conducting large scale thefts”

however, their only stated source for this analysis was a 150-word newspaper article that did not include any information about copper-theft suspects. The reference to “organized groups of drug addicts” seems particularly suspect, since drug addiction is commonly associated with disorganised lifestyles in which addicts find it difficult to organise themselves to take medication (Stein et al., 2000), care for children (Comfort et al., 1990) or work (Mugford, 1992).

In the UK, BTP estimates that up to 30% of metal-theft offences are committed by organised groups (House of Commons Transport Committee, 2012, p 11). Dottori et al. (2011, p 21) noted a perception – among European governments and in numerous newspapers – that offenders frequently come from Eastern Europe, particularly Roma communities. However, they stated that evidence to support this was largely anecdotal. Van Daele (2008) found that 18% of group offenders identified as repeatedly committing serious property crimes (including, but by no means limited to, metal theft) in Belgium were from Eastern European countries.

Electrical Safety Foundation International (2009) estimated that a quarter of US electricity distributors had experienced metal theft committed by their own staff or contractors, a problem also reported by Network Rail (House of Commons Transport Committee, 2012, p 11). The involvement of an employee may be attractive to organised crimes groups because it provides inside knowledge of opportunities for theft and because it may make offending safer.

#### 4.4.1 *What we don't know about metal thieves*

If those metal thieves killed or seriously injured while stealing metal are representative of metal thieves in general, it seems likely that offenders are predominantly adult men. At present, there is no information on the nationality of offenders, which in turn limits what can be said about the degree to which offenders are willing to cross borders in order to steal metal. Although there is a widespread perception that OCGs are involved in metal theft, there is almost no evidence that this is the case. Such evidence would be valuable because the techniques used in the fight against organised crimes such as drug trafficking or money laundering are generally quite different to those used against volume crimes such as burglary and domestic assaults. Thus if metal theft is erroneously believed to be an organised crime, this may lead the police to adopt tactics that are either ineffective or inefficient.

#### 4.5 CONCLUSION

Although academic interest in metal theft is greater than it was a decade ago, there are still fewer studies in this area than in the study of many other acquisitive crimes. This review has identified several gaps in the existing literature the investigation of which appears likely to have benefits both for the activities of practitioners and for the academic study of crime. Chapter 6 will attempt to analyse the problem of railway metal theft using a crime script in an attempt to identify which of these gaps should be prioritised for further work. Before this, the next chapter will describe the metal-theft data used in this thesis.







## DATA

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### SUMMARY

- Compared to other types of crime, there is little data on metal theft because it is often not collected by governments (for example in crime surveys) or the police.
- This thesis uses data from British Transport Police because it has been recording data on metal theft since 2007.
- These data cover the railway network in Great Britain in relation to Chapters 7 and 8 – Chapter 9 uses data for England and Wales.
- Police-recorded crime data are used because they allow for small-scale spatial and temporal analysis.
- Data from the police national computer are used to study offence methods because they allow use of the largest possible sample and because they are nationally representative.

## 5.1 INTRODUCTION

Chapter 4 highlighted that relatively little research exists on metal theft compared to many other types of acquisitive crime. One reason for this is that, as a new crime problem, relatively little data exists on which to base analysis.

Many police forces are unable to produce recorded-crime data for metal theft because of how crime-recording processes are structured. In England and Wales, for example, crime-recording systems typically aggregate crimes into the categories required for reporting statistics to the Home Office rather than recording every possible type of (for example) theft in a separate category. As a new crime problem, few forces have a category for 'metal theft', and so incidents may be recorded under several different headings. For example, theft of a catalytic converter from a car on the street could be recorded as a theft from a motor vehicle, while theft of a drum holding copper wire from a warehouse could be recorded as a non-residential burglary. Identifying which thefts from motor vehicles or burglaries are metal thefts can be problematic, particularly in forces that record too many crimes to make manual processing of datasets feasible. Research on metal theft therefore requires a police force that *does* record metal theft as a separate crime category.

At the time of this research the only force in England and Wales that recorded metal theft as a separate crime category was BTP, the national specialist police force for the railway network. Metal thefts from January 2007 onwards were recorded in separate categories because BTP recognised the particular vulnerability of the railway network and the risk of disruption discussed in Section 3.7. For this reason, the availability of data dovetailed

with the importance of metal theft to the functioning of the railway network to provide the focus for this thesis.

The empirical work presented here was based primarily on two datasets provided by BTP, one detailing recorded metal thefts and one listing suspected metal thieves. These were supplemented by datasets from other sources that are described in the relevant chapters.

## 5.2 CRIME DATA

The crime dataset provided by BTP included reports of 8,207 thefts of metal from the railway network between January 2007 and December 2012. Each record included the date and time on which the crime occurred, the offence location and a brief description of the method used in the offence.

This source of data was chosen because BTP began recording metal thefts much earlier than most law-enforcement agencies, and because the data cover an entire country. While there will undoubtedly be some thefts that have not been recorded by BTP, there are two reasons to believe that almost all crimes are recorded. Firstly, the theft of metal from the railway is usually known to the railway operator, who can then report it to the police. For example, when signalling cable is stolen from the side of a railway line, this should cause the signals in that area to fail and an alarm to sound in the relevant signalling-control centre (Bonnett, 2005, pp 131–137). Secondly, the railway operator is highly motivated to report offences to the police, in order to ensure that metal theft remains a high priority and to demonstrate the extent of the problem to government and other stakeholders (for examples of such lobbying, see House of Commons Transport Committee, 2012).

Police-recorded crime data were used because – although not all crimes are reported to police – such records are the only source of local information on metal theft. Alternative sources of data, such as surveys of victims or offenders, used for other types of crime are not available for metal theft. Carrying out such surveys would also be unlikely to be cost effective since, because live-metal theft causes substantial disruption to railway services, service providers are likely to be highly motivated to report it to the police. Even if surveys were practicable, they rarely provide sufficient temporal or spatial specificity to allow the types of analysis attempted in Chapters 7 and 8.

Figure 5.1: *An non-addressable railway location.*

Image: Richards (2013)



### 5.2.1 *'Live' and 'non-live' metal thefts*

BTP records metal thefts as being either of 'live' or 'non-live' metal, with metal regarded as being live if it was in use as part of the rail network at the time of being stolen, rather than being in storage, or in use in other ways (for example on the roofs of station buildings). Of the sample, 5,044 thefts (62% of the total) were of live metal.

The analysis of spatio-temporal patterns of metal theft presented in Chapter 7 used only the data on live-metal theft. A single type of metal theft was chosen for the analysis because of the importance of crime analysis being specific to a particular type of crime to maximise its usefulness (see Section 2.4.3). In Chapter 8, data was used on all metal thefts since SMDs could potentially be associated with the theft of non-live as well as live metal.

### 5.2.2 *Geo-coding offences*

Chapter 7 reports on spatial and temporal analysis of these data. One difficulty of this type of analysis is that it may not always be possible to determine



when or where some crimes occur. Offences occurring at unknown times are described as being “aoristic” (Ratcliffe and McCullagh, 1998). Crimes that involve theft or of damage to unguarded targets are particularly likely to be aoristic (Ashby and Bowers, 2012), with vehicle thefts, burglaries and criminal damage frequently occurring at unknown times (Ratcliffe, 2002, p 31). A particular problem for the analysis of crimes on transport networks is that they can occur on moving vehicles, in which case the victim may only be able to say that the offence occurred somewhere between two points – Newton et al. (2014a, p 1) referred to such offences as being “interstitial”.

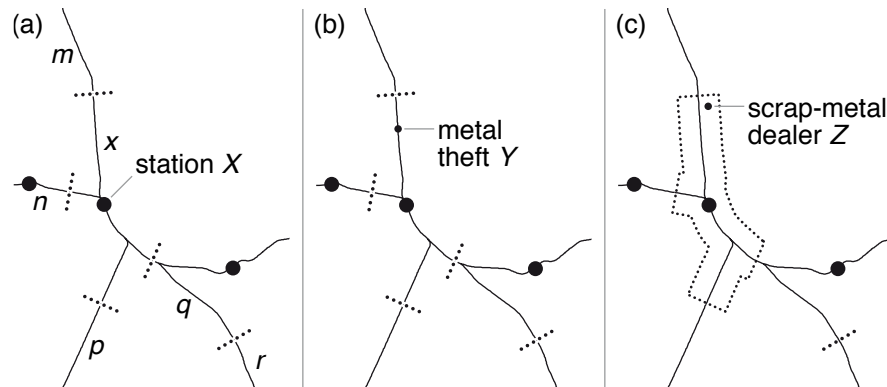
Even when offences against transport networks do not occur onboard vehicles, it may be difficult to specify their location accurately because network components such as railway tracks and telecommunications cables often pass through rural areas where locations cannot be described with references to addresses, road names or other features. Figure 5.1 shows an example of such a “non-addressable” (Chainey, 2002, p 7) railway location, which would be extremely difficult to locate on a standard gazetteer. The increasing availability of global positioning system (GPS) devices may alleviate this problem in future (Loewenberger et al., 2014, p 195), but this does not assist scholars seeking to conduct secondary analysis of crime data already collected by the police without the use of such technology.

In 2% of cases in the present dataset, there was insufficient information in the crime report to enable the crime to be geocoded to any location on the railway network. The resulting geocoding ‘hit rate’ of 98% is much higher than the minimum rate of 85% that Ratcliffe (2004) found was necessary in order to assume that the un-coded offences would not change the apparent distribution of crimes. However, Ratcliffe (2005, p 110) noted that the 85% threshold applies only if un-coded offences are believed to be randomly distributed. In the present study this assumption could not be made, because in some cases several crime reports gave the same un-codable offence location. Nevertheless a hit rate of 98% is higher than is commonly achieved by police crime analysts (Ratcliffe, 2010a, 9) and is similar to or higher than found elsewhere in the literature (see, for example, Andresen, 2006, p 266; Groff et al., 2010a, p 13; Ratcliffe et al., 2011, p 808).

Given the number of potential non-addressable railway locations, BTP commonly records line-side crimes as happening at the nearest of the 2,527 passenger stations on the network. This meant that, in the case of live-metal theft, 84% of offences were coded as happening at stations, even though

Figure 5.2: *Method for constructing buffer areas.*

The Voronoi polyline  $x$  for station  $X$  extends half-way to the next station in each direction (a). Metal theft  $Y$  is closer to station  $X$  in network distance than to any other station, so it is counted as occurring within polyline  $x$  (b). Likewise scrap-metal dealer  $Z$  is counted as being within the buffer area extending 2.7 kilometre (km) from polyline  $x$  (c).



fewer than 1% of offences happened within the confines of a station<sup>1</sup>. In order to reflect this spatial uncertainty in the present analysis, those few thefts that were not already recorded as occurring at stations were counted as happening at the nearest station. Since the nearest station in Euclidean space to a particular offence may be on a different railway line to the offence location, it was necessary to take into account the structure of the railway network during this matching procedure. This was done by calculating a Voronoi polyline for each station, where the polyline for each station included all the railway track that was closer (by network distance) to that station than to any other (Figure 5.2). The median Voronoi polyline was 3.9 km in length, with an interquartile range of 5.1 km. For the remainder of this thesis, references to offences at railway stations should therefore be read as offences occurring at a particular station or nearer to it than to any other station.

### 5.3 OFFENDER DATA

The second principle dataset, used as the basis for the analysis presented in Chapters 6 and 9, provided details on the personal characteristics and offending histories of known metal thieves along with the offence methods that they are known to use.

<sup>1</sup> The BTP crime data include a field known as the 'premises type', which identifies whether the crime happened in a station, on or at the side of the tracks, in a depot, in a car park and so on. All but 1% of metal thefts occurred at a premises type that indicated they occurred other than at a station.

For this purpose, BTP provided details of every person who had been arrested for metal theft from railway lines between 2007 and 2013. The National Crime Agency (NCA) then provided data on the criminal records of these offenders from the Police National Computer (PNC), as well as a summary of any intelligence information held on their involvement in organised crime.

BTP has been collecting data on metal thieves for longer than any other UK force, allowing the use of the largest possible sample. Although people who steal metal from the railway network may be different in some unknown way to those who steal metal from elsewhere, half of arrests for metal thefts in the sample did not relate to thefts from the railway<sup>2</sup>. As such, it is believed that the sample represented the best available source of information about metal thieves.

In England and Wales, police officers can arrest suspects if they have ‘reasonable suspicion’ that the person has committed an offence, for example because they match a description given by a witness (English and Card, 2007, p 58). It is a logical consequence of this police power that some people will be arrested even though subsequent information proves beyond doubt that they were innocent of the offences for which they were detained. It was necessary to take this into account by excluding those offenders who were suspected of involvement in metal theft without foundation. One way to correct this bias would be to exclude all those offenders who were not subsequently convicted of metal theft, but this would raise new issues. The criminal justice system is designed to avoid false convictions even at the expense of many false acquittals, while many reasons for acquittal do not relate to the accused’s guilt: a witness may die or move to another city, physical evidence might be lost and so on. The over-riding duty to prevent false convictions is essential in court, but criminological research requires a finer balance of risk between falsely including or excluding cases: using only convictions would prevent false positives, but at the expense of ignoring the problem of false negatives. To strike this balance, offenders were included in the final sample if they had been either charged with or cautioned for a metal theft (referred to below as being sanctioned for that offence). Both of these processes require that the evidence in the case satisfy the test set out in the Code for Crown Prosecutors, which requires that a person may only be sanctioned if a prosecutor (or in certain minor cases, a specially trained police officer) believes

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<sup>2</sup> Since metal theft is not a distinct crime category on PNC, all theft offences were categorised into metal and non-metal thefts based on the narrative PNC offence method.

“that an objective, impartial and reasonable jury . . . is more likely than not to convict the defendant of the charge alleged” (Crown Prosecution Service, 2013, p 6).

For a person to be cautioned, not only must there be sufficient evidence but the offender must also admit the offence. Of the 1,084 people in the initial sample (i.e. all those who had been arrested by BTP for metal theft), 243 were excluded because they had never been sanctioned for a metal theft. A further two offenders were excluded because of apparent mistakes in recording their details on PNC, so the final sample consisted of 839 offenders. Individual offences were included in the analysis only if the person had been sanctioned for that offence. This resulted in a final sample of 1,599 offences for use in this analysis.

Due to restrictions on the use of sensitive personal data, it was not possible to obtain data on other offenders (i.e. those who have never been arrested for metal theft) to form a control group. In order to minimise the extent to which this absence limited analysis of the data that were available, in Chapter 9 comparisons are made to other sources (e.g. Gregory, 2003; van Daele and vander Beken, 2009; Francis et al., 2013), where possible.

### 5.3.1 *Offence methods data*

Each PNC record include details of all the offences for which an offender had been arrested. The information provided about each offence includes a free-text description – written by the investigating officer – of the offence method (*modus operandi*). The descriptions are relatively short (median length 29 words), limiting what could be elicited from them. A typical example of description was:

“Suspect and younger friend . . . walked past a quantity of lead in an alleyway, returned home to pick up a bag then returned and placed [the metal] in a holdall to sell it at a local scrap merchant.”

A more-detailed source of method descriptions would have been the case files submitted by officers at the conclusion of an investigation. However, these are held by individual police forces (often on paper) and so it would have been impracticable to obtain a national picture in this way.

To create a reasonably sized corpus for analysis, methods for 400 metal thefts (25% of all metal thefts in the sample) were randomly selected. This

corpus was used as the basis of the crime script discussed in Chapter 6. Although crime-script analysis is becoming increasingly common in the literature (see Section 2.5.1), there is as yet no agreement on the method for constructing a script nor type of data on which a script should be based. Tompson and Chainey (2011, p 187) described how crime scripts can be constructed by “thinking thief ... a combination of expert knowledge, interviews with offenders, crime scene analyses of *modus operandi* and a degree of inference from those intimate with the case”. Brayley and Cockbain (2011, 134) adopted a similar approach but used records of police interviews with suspects in lieu of interviews by researchers, while Chiu et al. (2011) used transcripts of court hearings.

In the present case, offender interviews would have been likely to be unrepresentative because such interviews typically take place in prison – see, for example, Beauregard et al. (2007) – and very few metal thieves receive long-enough prison sentences to allow interviews to take place. Using police interviews would also have been difficult because recent changes to the funding of legal-aid mean solicitors may be increasingly likely to advise suspects to make no comment when questioned by police (Kemp, 2012, pp 54–56). Likewise, it was not possible to rely on court transcripts because a large proportion of metal-theft cases are heard in magistrates’ courts, in which proceedings are not transcribed. The lack of alternative data made the offence methods recorded on PNC the most-appropriate source for information from which to generate a crime script. The method by which these descriptions were analysed is discussed further in Section 6.2.

#### 5.4 SOFTWARE USED IN THIS THESIS

Multiple, mixed methods were used to produce the analysis presented in this thesis, and are described in the relevant empirical chapters. Except where noted, spatial analysis was conducted in ArcGIS 10.1 (ESRI, 2012). Non-spatial analysis was conducted in R (R Core Team, 2013), with the ‘circular’ package (Agostinelli and Lund, 2011) used for calculating circular statistics and the ‘CAR’ and ‘MASS’ packages (Fox and Weisberg, 2011; Venables and Ripley, 2002) used for regression models. The near-repeat calculator (Ratcliffe, 2009) was used in the analysis of repeat and near-repeat offences and NVivo (QSR International, 2014) was used for qualitative analysis of offence methods.







## A CRIME SCRIPT FOR RAILWAY METAL THEFT

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### SUMMARY

- The process of metal theft can be broken down into five units: becoming motivated to steal metal from a specific location, preparing to steal, stealing the metal, preparing the stolen metal for resale and selling the metal for profit.
- Each unit can be broken down into functions, with each function being moderated by factors such as the vulnerability of metal and the activities of controllers against crime.
- Functions are also dependant upon the availability of tools such as vehicles and handlers of stolen goods.
- The script is used to identify three areas that are feasible for further study and have the potential to be useful for the prevention or detection of metal theft. These are the spatial and temporal distribution of thefts, the involvement of scrap-metal dealers and the degree to which metal theft is driven by organised-crime groups.

## 6.1 INTRODUCTION

As discussed in Section 2.5, any crime is a series of actions that together make up a process. In this chapter a crime script will be constructed outlining the process of metal theft from railway networks. The first section describes how the script was derived, the second describes the script itself and the third outlines the extent to which the script meets the quality-assurance criteria outlined by Borrion (2013) and discussed in Section 2.5.1. The final section of this chapter will identify features of the script that offer potential avenues for understanding and preventing metal theft on railways, which will be the subject of the empirical chapters that follow.

## 6.2 DEVELOPING THE SCRIPT

Crime scripts can be constructed at several levels of abstraction, and the choice of level will reflect the tension between being crime-specific (see Section 2.4.3) and producing knowledge that is sufficiently generalisable to be useful for preventing crime in the future (see Section 2.3). In the case of metal theft from railways, there are several different types of offence (see Section 3.6) that could each be represented by a different script. For example, theft of heavy drums of signalling cables from railway-maintenance depots requires access to a large vehicle but little specialist knowledge, while theft of high-voltage earth-return cable from alongside railway lines may not require a vehicle but will need sufficient electrical knowledge to help the thief avoid a potentially fatal electric shock.

The script presented here was devised to allow a combined analysis of different types of railway metal theft. Taking such an approach is not free



of risk: if the characteristics of different types of railway metal theft are substantially different from one another, attempting to analyse them together is likely to be unsuccessful. Conversely, constructing multiple very-specific scripts would risk obscuring common features that could be used to provide common solutions to different types of railway metal theft. The latter concern is particularly important because as scripts are made more specific they are necessarily based on fewer cases, potentially reducing the extent to which they may be generalisable to future incidents.

As described in Section 5.3.1, there is no single accepted method for generating crime scripts. Different scholars have used varying methods, several of which would have been impractical in the present case. Given these limitations, the script presented here was based on three sources of information. The first was the theoretical framework provided by the routine-activities approach, which was used to identify the different roles that could be played in relation to a metal theft. For example, this framework suggested that a necessary precursor to an offence occurring was that a potential offender would be motivated to steal metal from the railway (see Section 6.3.1). Using this framework allowed the script to incorporate findings from the many previous analyses of particular types of crime that have used the routine-activities approach.

Within that theoretical framework, the main source of data used to generate the script was analysis of the random sample of 400 metal-theft methods described in Section 5.3.1. The purpose of this analysis was to identify recurrent features of metal thefts for which offenders had been identified. For example, this analysis demonstrated that offenders often used vehicles to transport stolen metal (see Section 6.3.2) and that metal is typically sold to SMDs (see Section 6.3.5). All of the information in the script is derived from this source of data, except where otherwise noted.

Since the offence descriptions were usually short, they were supplemented by the third source of information: informal discussions with practitioners, particularly BTP and NCA investigators. Metal-theft methods were also discussed with practitioners at some of the conferences listed on page 11. These discussions helped provide additional context to the theoretical framework and the description of offence methods, but they were not the basis on which the script was developed. The discussions were held informally in order to allow practitioners to speak freely, but this precluded the recording of interviews, which would likely have led to many practitioners feeling

unable to discuss issues related to police investigations. In the absence of such recording, the conversations could not be used as a robust source of evidence on which to base the script, and were instead used to help the author understand some of the patterns identified in the offence-methods data.

While this approach to constructing a crime script followed existing practice, the literature evaluating different methods for generating crime scripts remains under-developed. As such, little guidance is available on which methods are most likely to produce a useful script: further research in this area would be very useful. To ensure that the method used here was appropriate, the quality-assurance framework described in Table 2.1 will be applied to this script in Section 6.4.

### 6.3 A CRIME SCRIPT FOR RAILWAY-METAL THEFT

Figure 6.1 shows a summary form of the crime script produced for railway metal theft during this research. The script consists of five units, each of which is broken down into several lower level functions. As described in Section 2.5.1, the diagrams in this chapter use IDEF0 notation (for a key to this notation, see Figure 2.1). Each function in the script is identified by an alpha-numeric designation, shown in the bottom right-hand corner of the function box<sup>1</sup>.

#### 6.3.1 *Becoming motivated to steal metal from a specific location*

Unit A (Figure 6.2) describes the process of an offender becoming motivated to steal metal from a particular railway site at which they know an opportunity to steal metal exists, corresponding to the “preparation” stage outlined by Thompson and Chainey (2011). This process can be broken down into two parts: the development of motivation (function A1) and the identification of a site containing vulnerable metal (A2).

The question of how an offender becomes motivated to commit crime is far too broad to be done justice to in this thesis: Smart (2003, p 489) called

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<sup>1</sup> Functions in IDEF0 models can be nested within one another, but continue to be referred to as functions regardless of their position in the hierarchy of other functions. Differentiation is achieved by reference to the function numbers. For example, function B1 is nested within function B. However, since the present script has only two levels, functions at the upper level will be referred to as units to reduce confusion, and for compatibility with previous literature on crime scripts.

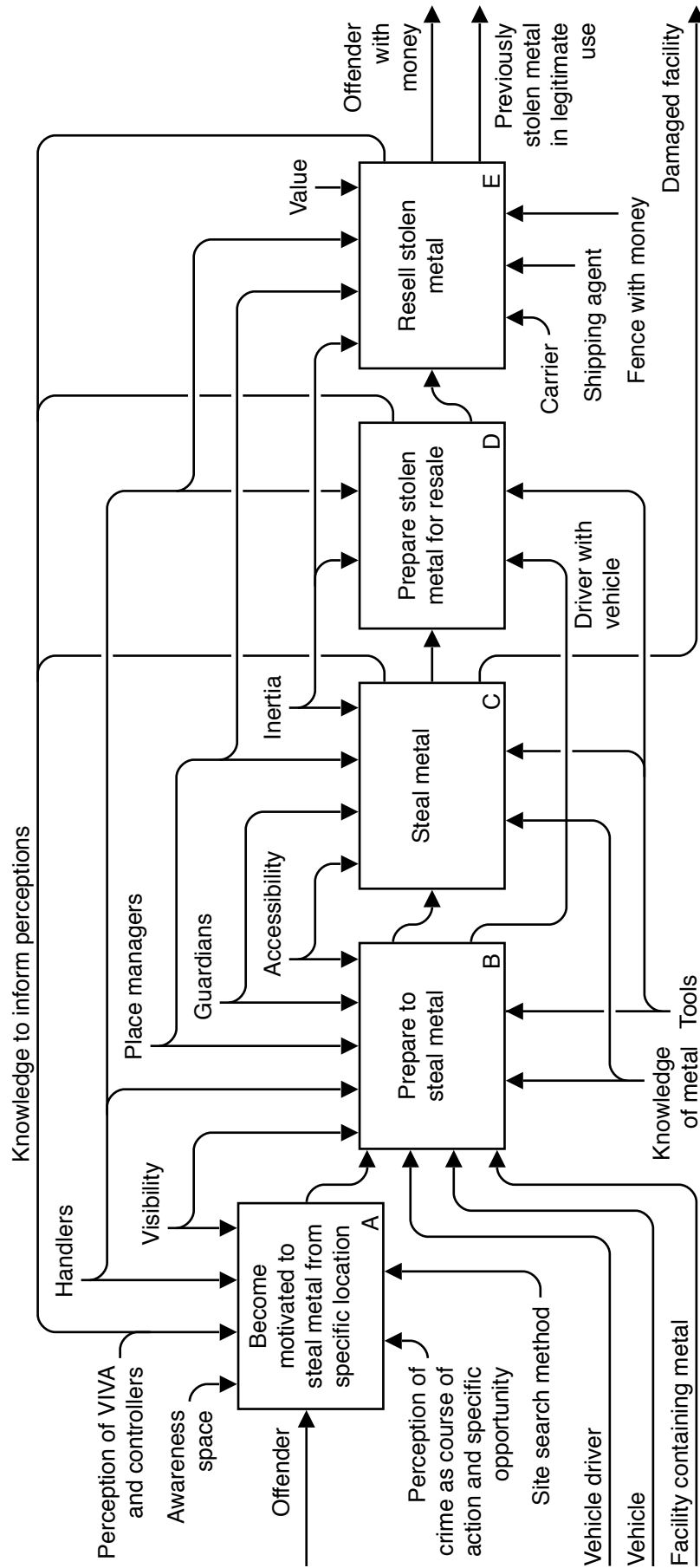


Figure 6.1: *Process of metal theft from railway networks.*

it “the central question” of criminology, and as such it has been subject to voluminous research. However, this work has been largely inconclusive: Lipman et al. (1985, p 63) remarked that “at times it seems that modern criminology is no closer to a solution to the question of why people engage in criminal behaviour than they were a century ago . . . in many ways the search for a cause of crime is a lost cause”. Similarly, Farrington (1988, p 75) argued that “while a good deal is known about the correlates of delinquency and crime, there is surprisingly little agreement about its causes”<sup>2</sup>. This lack of progress led Clarke (1980b, p 136) to criticise criminologists for “dispositional bias” (a term previously coined by Haney and Zimbardo, 1974, pp 1–9): the tendency for scholars to focus on what motivates people to commit crime rather than on what causes or permits the crime itself to occur, limiting the ability of scholars to study crime-prevention strategies related to the crime rather than the criminal.

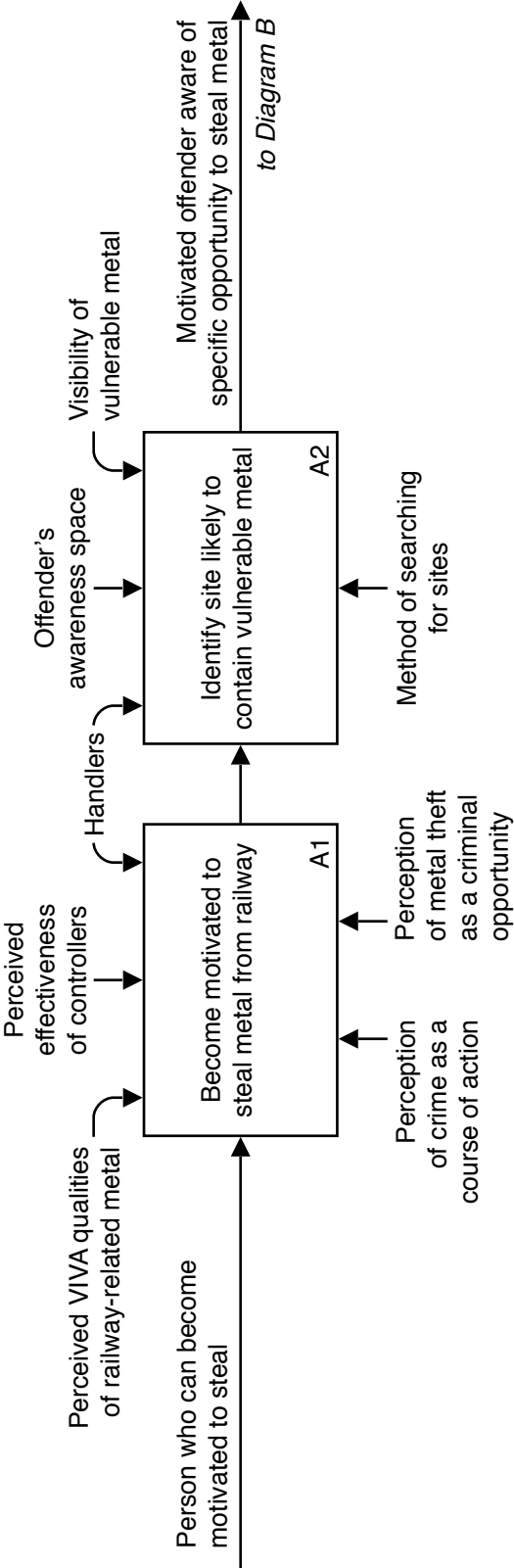
Given the enormous spectrum of potential dispositional causes of crime, the lack of agreement about the importance of specific examples of such causes, and the limits that a dispositional approach may put on any ability to prevent crime, dispositional factors will not be considered in detail within this script. This should not be taken as a suggestion that dispositional factors are not important, but rather as a reflection of the impracticality of including them all in a crime script. Consistent with the theoretical framework outlined in Chapter 2, function A1 (Figure 6.2) refers to two mechanisms that combine to determine the likelihood of potential offenders becoming motivated to steal metal from the railway. The first, borrowed from the situational action theory described by Wikström (2004), is the process by which offenders come to perceive of crime as a potential course of action. Variations in dispositional factors will mean that some people are more likely than others to perceive committing a crime as a potential course of action when presented with a particular situation, and so are more or less likely to be motivated to commit crime. However, perception of crime as a potential course of action is not enough: potential metal thieves must perceive of *railway metal theft specifically* as a criminal opportunity. Both mechanisms are required in order for a person to be motivated to steal metal from railways.

If both mechanisms operate for a particular person, the likelihood of their becoming motivated to steal railway metal is controlled by three factors. Two controls relate to the offender’s perceptions, firstly of the VIVA qualities

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<sup>2</sup> For further discussion of this problem, see Wikström (2010, p 212).

Figure 6.2: *Process of becoming motivated to steal metal from a specific location (Unit A).*



of the types of metal that can be found on railways (see Section 2.6.2) and secondly of the likely effectiveness of potential controllers of crime (see Section 2.6). The third control is the *actual* effectiveness of offender handlers in influencing offender motivation.

Offender perceptions are likely to be influenced in part by any knowledge they have of previous metal thefts, either thefts they have committed themselves or ones they have knowledge of through acquaintances or the media. To account for this possibility, Figure 6.1 includes a feedback mechanism<sup>3</sup>.

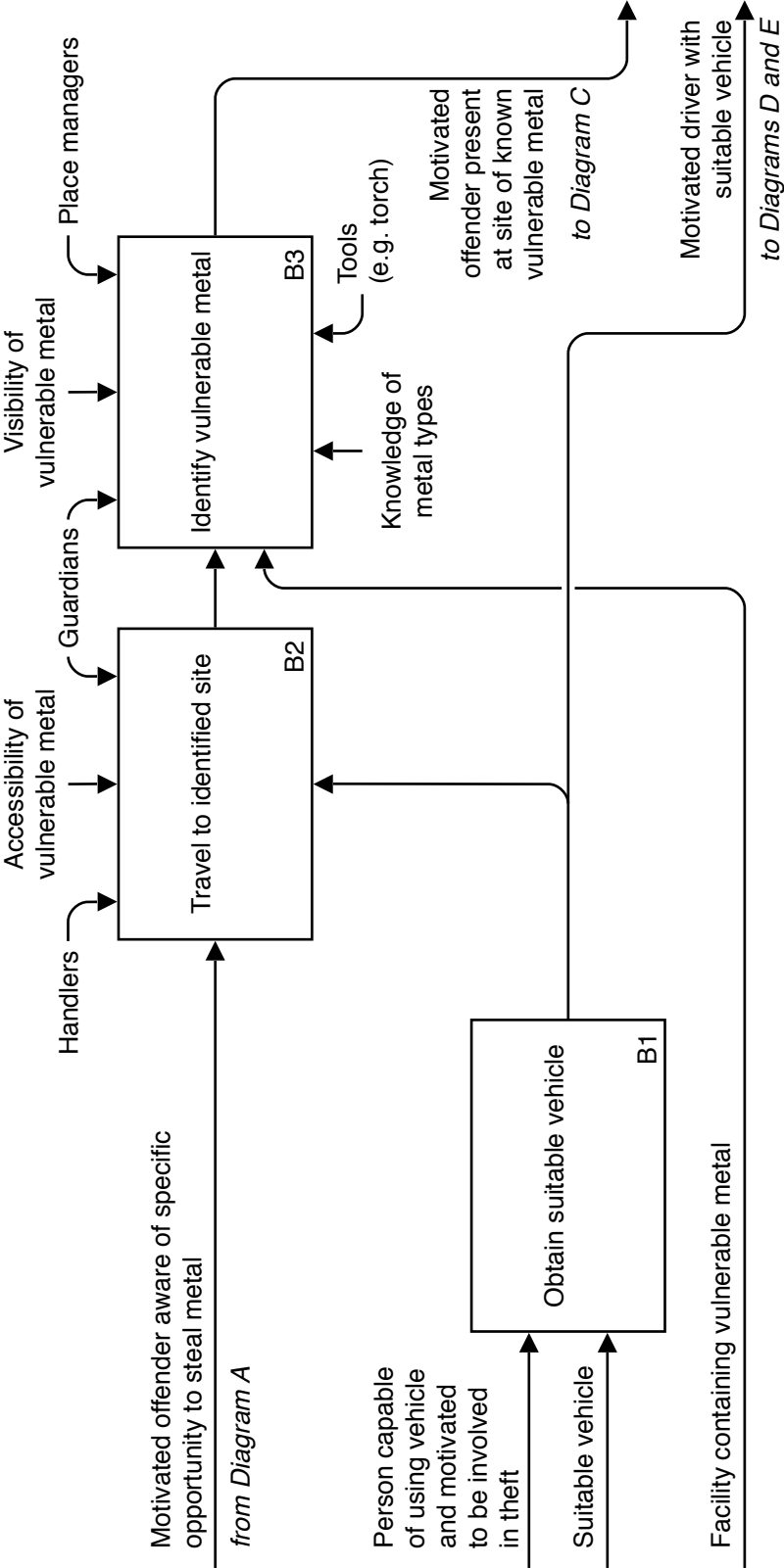
Assuming that an offender has become motivated to steal metal from the railway, the next function is to identify a site likely to contain vulnerable metal (function A2 in Figure 6.2), requiring a method of searching for suitable sites. This may take the form of an “optimal forager” search strategy (Johnson and Bowers, 2004; Johnson et al., 2009) in which offenders balance the benefits of finding the ‘best’ (most-vulnerable, highest-value etc.) site with the costs of travelling further from their base location (for a discussion of related issues, see Rossmo, 1999, p 126). Of key importance is likely to be the influence of a potential offender’s awareness space (see Section 2.6.6): an offender whose activities frequently bring them close to railway lines is likely to find it easier to identify a site likely to contain vulnerable metal than one who lives and works in an area with no railways. The visibility of different types of vulnerable metal is also likely to influence target identification: railway companies have begun to bury line-side cabling in some areas in an attempt to prevent metal theft (House of Commons Transport Committee, 2012, p 17). Finally, at this stage handlers may still be able to control potential offenders, for example a person motivated to steal metal may be unable to do so if they live with parents who monitor them closely.

### 6.3.2 *Preparing to steal metal*

The functions discussed so far produce a motivated offender aware of a specific opportunity to steal metal from a railway. The next unit (Figure 6.3) – which corresponds to the “pre-activity” stage described by Thompson and Chainey (2011) – consists of obtaining suitable transport (function B1), travelling to the identified site (B2) and identifying vulnerable metal once at the site (B3).

<sup>3</sup> For reasons of space, this feedback arrow is not shown in the low-level IDEF0 diagrams, but should be read as if the offender’s experience of each function will potentially influence their perceptions of the effectiveness of controllers and the VIVA qualities of metal on railways.

Figure 6.3: *Process of preparing to steal metal (Unit B).*



Some very-small-scale metal thefts may be possible without a vehicle. For example, one case in the sample of methods studied to produce this script involved offenders who carried away lead in a sports bag (see Section 9.8). However, the weight of most saleable quantities of metal will mean that a conveyance is often required even if, as in at least one case in the sample, the conveyance is a shopping trolley. Function B1 has two inputs: a suitable vehicle and a person to use it. To be suitable, a vehicle must be both capable of carrying the metal to be stolen and promote, or at least not hinder, the likelihood of the offender being able to steal metal without being apprehended. For these purposes, the methods sample suggested that panel vans were common for this purpose, presumably because they are both capable of carrying as much cable as a person can carry and because they are very common on UK roads. The person using the vehicle may either be the offender already discussed in the previous section, or another person (in which case that person will have gone through a motivation process as described in the previous section). Some methods in the sample mentioned an offender passing cable – for example through gaps in a boundary fence – to a driver accomplice.

The output of function B1 (a suitable vehicle and driver) acts as the mechanism for function B2, the offender travelling to the identified site. As discussed previously, the routine-activities approach suggests that the ability of offenders to move towards a suitable site can be influenced by the capability of handlers. The ability to complete function B2 is also likely to depend upon the accessibility of vulnerable metal, which is likely to vary according to its location and characteristics. Finally, the ability of an offender to travel will probably be influenced by the capability of guardians (see Section 2.6.2). It should be noted, however, that the factors controlling function B2 could not be validated using the methods sample, because police officers are typically unaware of all of the factors influencing offender location choice and travel distance at the time at which they record the offence method. As such, this part of the script was generated based upon the theoretical predictions of the routine-activities approach.

Once an offender has travelled to the site, it will be necessary for them to identify any vulnerable metal that is present, requiring knowledge of different types of metal and their appearance<sup>4</sup>. An offender must also have any necessary tools, although in many cases in the sample only simple hand

<sup>4</sup> British Transport Police (2011, p 4) described a case where offender did not have this knowledge and so cut up quantities of fibre-optic cable, erroneously believing it to be copper.



tools were mentioned. As well as guardians, an offender's ability to complete this function is likely to be influenced by the visibility of the metal (see Sections 2.6.2 and 3.3) and by the capability of any place managers (see Section 2.6.3).

### 6.3.3 *Stealing metal*

Unit C (Figure 6.4) corresponds to the "activity" stage described by Thompson and Chainey (2011) and is broken down into three parts. Firstly (function C1), the offender must access the vulnerable metal that they identified in function B3. Although this could not be discerned from the offences methods, the routine-activities approach suggests that the likelihood of completing this function will be controlled by the accessibility of the vulnerable metal, as well as by the capabilities of place managers (e.g. railways signallers) and guardians (e.g. local residents whose properties overlook the railway). Once an offender has gained access to a metal item, they must extract it (function C2). In some cases this will be as simple as picking up scrap metal discarded on the ground by maintenance workers (as was commonly recorded in the methods sample), but in other cases may require particular tools or knowledge of metal handling. The sample of methods suggested that this was typically done using hand tools such as hacksaws, wire cutters or (for thicker cable) bolt croppers. In any case, the ability to complete this function will be controlled by the capabilities of guardians and place managers, and by the inertia of the metal concerned. Similar considerations will influence function C3, the cutting-up or packaging of stolen metal for transport, if required. In the sample of methods under study, offenders appeared to cut-up stolen metal when it was too big to be carried by hand or to fit into a van. This was particularly the case for stolen rail or long lengths of signalling cable.

### 6.3.4 *Preparing stolen metal for resale*

Units D and E together correspond to the "post-activity" stage described by Thompson and Chainey (2011). The input to unit D (Figure 6.5) is a motivated offender in possession of cut-up stolen metal, which must now

Figure 6.4: *Process of stealing metal (Unit C).*

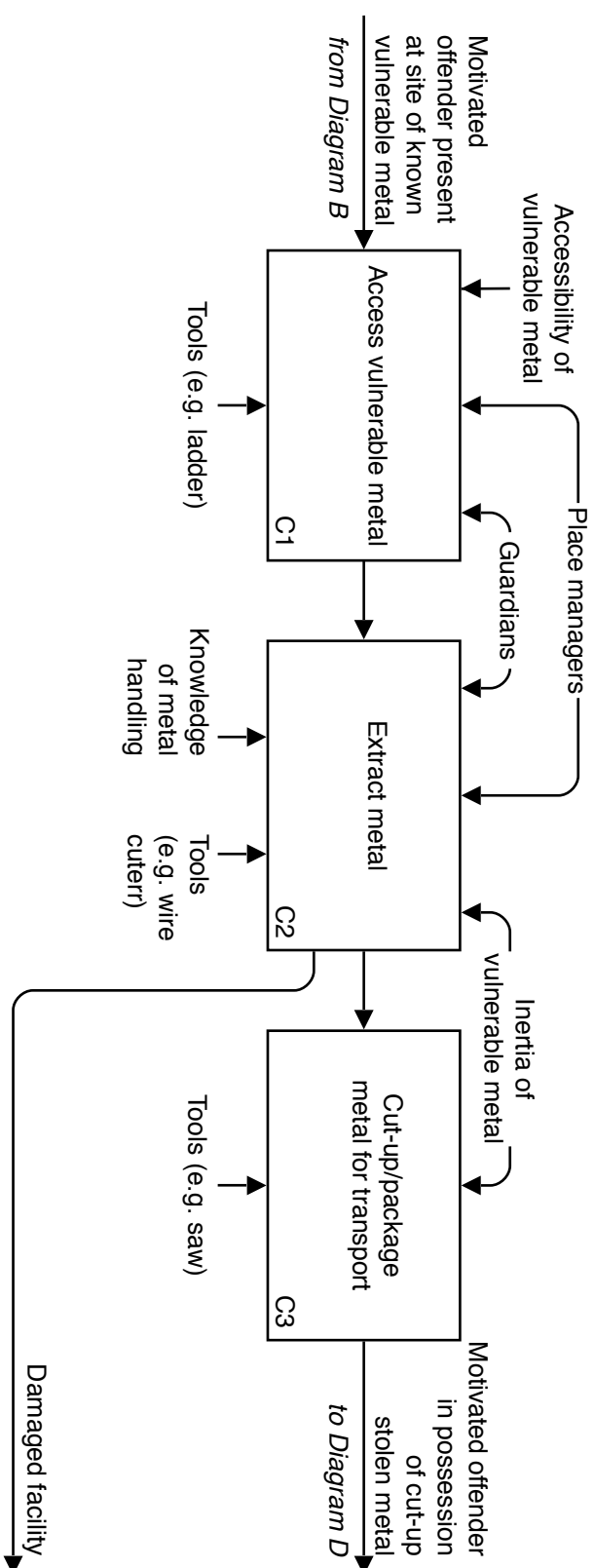
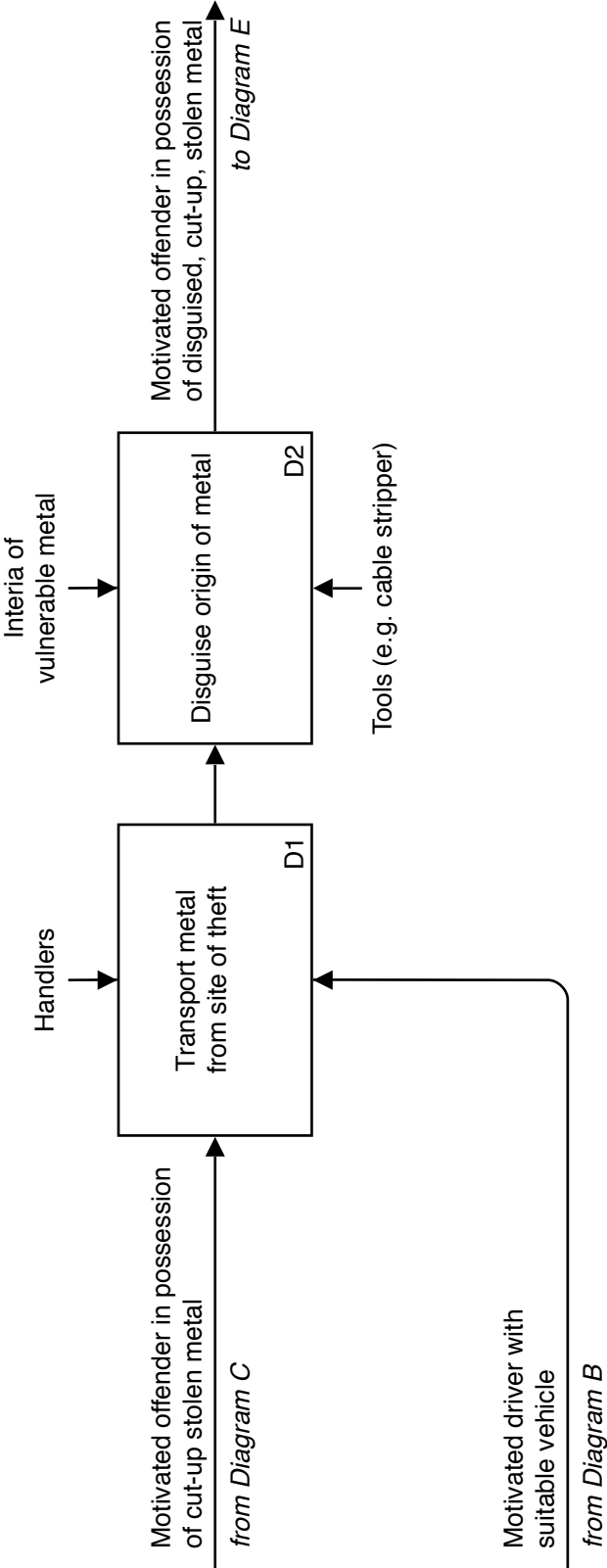


Figure 6.5: *Process of preparing stolen metal for resale (Unit D).*



be transported away from the theft site (function D1), controlled by the capabilities of offender handlers<sup>5</sup>.

Function D2 involves disguising stolen metal to obscure the fact that it is stolen. This may not always be necessary, if there is someone willing to buy the metal from the offender even though it is clearly stolen and can be identified as such. However, the offenders may get a better price for metal that appears to be in their legitimate ownership, and metal that is not obviously stolen is less likely to attract the attention of the police or anyone who might pass information onto them. Being able to obscure the origin of items is likely to be particularly important because of the frequent checks that police undertake at SMDs looking for stolen metal (Lipscombe and Bennett, 2012). This may be why methods in the sample often included mention of offenders stripping the plastic or rubber sheathing from around copper cables, since those sheaths often carry identification markings.

#### 6.3.5 *Reselling stolen metal*

The final unit in the model is the reselling of the stolen metal and consequent realisation of benefit for the thief (unit E, Figure 6.6). Discussions with practitioners identified two main ways in which this can be accomplished: by the thief exporting it directly to a user in another country (functions D1 and D2) or by selling the metal to a fence with the UK (functions D3 and D4), of which the latter is likely to be easier and more common because it requires far less expertise. In either case the stolen metal must be transported to the point of resale (functions D1 and D3), using the driver-and-vehicle mechanism previously described and controlled by the inertia of the metal. The function of exporting stolen metal directly (D2) requires the involvement of a shipping agent and a freight carrier, either of whom could act as handlers if they took action to influence the offender, for example by requiring proof of ownership before accepting goods for transport. Place managers, such as port companies, may also control this function. However, there were no cases of direct export in the sample, and so little is known about them.

In the case of local sale, function D4 requires a fence and is likely to be controlled by the value of the metal for sale at current prices, and by the

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<sup>5</sup> One example of such handling, recounted to the author by a police officer engaged in investigating metal theft, involved railway-maintenance workers who stole metal and used a company vehicle to transport it to a scrap-metal dealer for sale. The offenders were unaware that all company vehicles were fitted with tracking devices that allowed the company to inform police of their illicit activities.

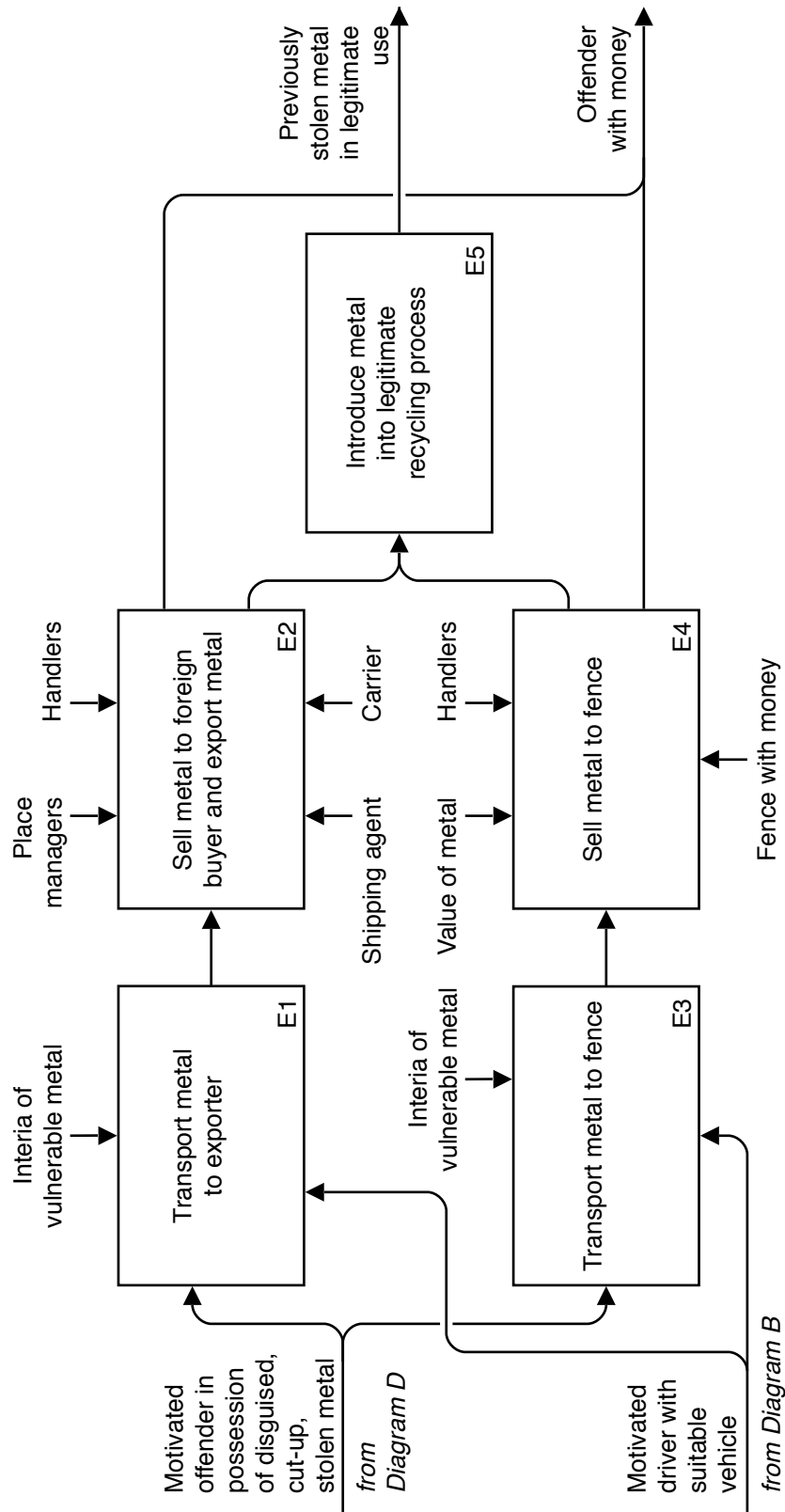


Figure 6.6: Process of reselling stolen metal (Unit E).

activities of handlers. Only at the end of unit D do the thieves realise any benefit from their activities. The importance of realising a benefit from their activities was shown by several offenders in the sample telling police that they intended to sell the metal they had stolen on at a scrap yard.

#### 6.4 QUALITY ASSURANCE

As discussed in Section 2.5.1, Borrión (2013) outlined a checklist for assuring the quality of crime scripts. While it may not be necessary to routinely include the result of such a checklist in published research outputs, in the present case one is included at Appendix A to illustrate how the checklist can be used.

Many of the criteria set out in the checklist are met here because of the use of IDEF0 notation. In particular, this ensured that the relationship between script elements was traceable, that the visual representation was consistent and (to the extent reasonably foreseeable) that the content was unambiguous. The use of well-defined notation also allowed the visual representation of the model to be parsimonious.

The use of this notation does have some limitations, however. In particular, IDEF0 does not provide any way to indicate how certain the modeller is about each aspect of the model. While business processes (for which IDEF0 was designed) can typically be observed directly and described with a high degree of certainty, this is not true with criminal processes. Offenders, for example, may go to some lengths to hide their activities from observation, and when interviewed (particularly as part of the judicial process) often have an incentive to lie. Greater uncertainty is associated with some functions in the current script than for others. In particular, there may be controls on the functions that are not shown in the script because they were not apparent in the available data and were not known to the practitioners with whom the script was discussed. Nevertheless, the script represents a summary of the available information on metal theft from railways, and so may be the best information available from which to identify potential opportunities for understanding and preventing metal theft.

## 6.5 OPPORTUNITIES FOR UNDERSTANDING METAL THEFT AND THE OBJECTIVES OF THIS THESIS

The crime script presented in this chapter and the literature review in Chapter 4 suggest several potential areas of further research into the problem of metal theft from railway networks. The present thesis will attempt to further understanding in three of these areas, chosen because they fulfilled two criteria. Firstly, the topics must be feasible, in that data are available and capable of being analysed. Secondly, the topics must be useful, in that it must be aimed at producing information, not already available, that is valuable in improving the prevention or detection of crime (see Section 2.2).

One notable feature of the script is the apparent importance of the routine-activities approach in explaining factors that influence the different stages in the act of stealing metal from railways. For example, handlers appear to have more potential influence during the pre- and post-activity phases but less during the theft itself, while the opposite is true for place managers and guardians. The influence of the VIVA qualities of metal also varies: visibility is important before theft, accessibility before and during the theft, inertia during and after, and value (as distinct from perceived value) only when it comes to reselling the stolen goods. The routine-activities approach has frequently been used in the past to understand concentrations of particular types of crime, particularly concentrations in time and in space, but such analysis is currently lacking in the study of metal theft (as discussed in Section 4.3). Therefore in Chapter 7, the consequences of routine activities for *spatial and temporal patterns of metal theft* will be discussed, with particular reference to those patterns that might influence the decisions of police or other managers wishing to deploy resources to prevent metal theft.

Two features of the script suggest an important role for fences in metal theft. Firstly, fences are the gatekeepers to a thief being able to realise any benefit from their activities (function D4 in the script). Secondly, the feedback mechanism described in Section 6.3.1 suggests that the ease with which a thief is able to complete function D4 may influence their perception of the benefits of stealing metal. This, in turn, may influence their motivation to steal metal in the future – an example of the thinking behind the market reduction approach (MRA) to crime prevention (Sutton et al., 1998). Chapter 8 will therefore discuss the *application of the MRA in relation to railway metal*

*theft*, and in particular will test the validity of the hypothesised feedback loop that underlies it.

Finally, one feature of the crime script that may be surprising to practitioners is that it suggests that – with the possible exception of a driver – the theft of railway metal can be accomplished by a single individual without the apparent need for the type of support system commonly associated with organised crime groups (OCGs). This is contrary to the frequent suggestion among practitioners that a substantial minority of metal thefts are associated with OCGs (see Section 9.1). Chapter 9 will therefore address this apparent discrepancy by attempting to *determine the extent to which OCGs are involved in metal theft in the UK*.











## SPATIAL AND TEMPORAL PATTERNS OF METAL THEFT

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### SUMMARY

- This chapter uses the routine-activities approach to identify spatial and temporal concentrations of metal theft from the railway network in Great Britain.
- Metal thefts are concentrated in a small number of hotspots, which are themselves spatially concentrated.
- In contrast to many types of acquisitive crime, metal thefts appear to concentrate around cities rather than in inner-city areas.
- Metal thefts occur most often at night but exhibit less annual seasonality than many other types of crime.
- The vulnerability associated with repeat targeting of particular locations appears to last longer for metal theft than for other types of crime previously studied.

### 7.1 CONCENTRATIONS OF CRIME

Section 2.6 introduced the routine-activities approach to understanding crime, which emphasises the importance of the role of the environment – and those people in it – in shaping patterns of crime. Since the motivation of offenders, the suitability of targets, the criminogenic nature of places, and the capability of controllers and super controllers will all vary non-randomly, one of the core predictions of the routine-activities approach is that crime will be unevenly distributed in time and space.

The study of crime concentrations has a long history, a full discussion of which is beyond the scope of this thesis – for detailed discussions, see Johnson (2010b) and Weisburd et al. (2012, Chapter 2). Analysis of many crime types has shown offences to be concentrated both in time and space. For example, residential and non-residential burglary (Bowers, 1999, p 169; Townsley et al., 2000, p 51; Ceccato et al., 2002b, p 42), street robbery (Bernasco and Block, 2011, p 34; Braga et al., 2011; Thompson and Bowers, 2013a, p 623), thefts from shops (Nelson et al., 1996; Fitzgerald et al., 2004; Cheng and Williams, 2012) theft of motor vehicles (Barclay et al., 1996; Rengert, 1997; Chainey et al., 2008), homicide (Block and Block, p 162; Morenoff et al., 2001; Braga et al., 2010) and terrorist attacks (Demirci and Suen, 2007; Braithwaite and Johnson, 2012; LaFree et al., 2012) have all been shown to exhibit spatial and temporal concentration. Sherman et al. (1989, p 38) found that half of police calls for service in Minneapolis were to 3% of addresses, with 40% of addresses producing no calls for police.

Weisburd et al. (2009) charted the increasing geographic specificity of the study of spatial crime variations, from 19th and early-20th Century studies of differences between regions, through mid-20th Century neighbourhood-level

studies to modern research on smaller areas. Recent research has demonstrated the importance of studying small spatial units to avoid obscuring important micro-level spatial variations in crime (Groff et al., 2010b, p 24; Johnson, 2010b, p 351).

Recent research on spatial crime concentrations has tended to focus on places – as described in the routine-activities approach (see Section 2.6.3) – as the unit of analysis, although in this context high-crime places have usually been referred to as crime hotspots (for a discussion of varying definitions of crime hotspots, see Farrell and Sousa, 2001, pp 228–9). Brantingham and Brantingham (1995) distinguished types of hotspot based on how the opportunity structure within them facilitates a high level of crime. *Crime generators* are places that attract large numbers of people for reasons unrelated to crime, but which in doing so allow the frequent convergence of potential offenders and potential targets. *Crime attractors*, conversely, are places that attract people specifically for criminal purposes, because they are well-known to provide frequent opportunities for crime. Clarke and Eck (2003) added a third type of hotspot that they called *crime enablers*, places to which offenders are attracted because those places are known to lack place management, making it easier to offend when opportunities occur.

Places that are not crime hotspots were referred to by Brantingham and Brantingham (1995) as *crime-neutral places*: these are not necessarily crime free, but they do not attract large numbers of offenders because they are not known to offer unusual levels of opportunity. Although sometimes presented as such, generators, attractors and enablers are not mutually exclusive: a place may attract many people for reasons unrelated to crime (and therefore be a crime generator) and simultaneously attract offenders for reasons specifically related to crime. Transport interchanges, for example, may fall into both types (Brantingham and Brantingham, 1995, p 7–8), generating assaults because of the large number of people present and attracting pickpockets because crowded places create many criminal opportunities (see Newton et al., 2014b).

## 7.2 THIS CHAPTER

As an emerging crime problem, the study of metal theft is only at the start of the process of increasing geographic specificity outlined by Weisburd et al. (2009), with most studies focusing on regional variation. For example, the

American Association of State Highway and Transportation Officials (2013) and the Home Office (2013) reported that metal theft was concentrated with a few US states and UK counties. The only sub-regional study of which the author is aware was by Posick et al. (2012), but this analysed data for only one city (for further discussion of these studies, see Section 4.3).

There are likely to be both theoretical and practical benefits to studying the spatial and temporal distribution of an emerging crime type. Most research on theft has concentrated on the types of theft most commonly experienced in developed countries, for example theft of and from vehicles, burglary, robbery and shoplifting. From these studies have come a number of rules-of-thumb on the concentration of theft (and indeed high-volume crime more generally), for example the “iron law of troublesome places” (Wilcox and Eck, 2011, p 476) discussed below. These rules can usefully be tested on a new type of theft not previously studied in detail to determine whether they still apply. As well as being useful for the academic community, the increasing popularity of evidence-based policing (Sherman, 1998; Lum and Koper, 2014) means these same rules are now being used by practitioners to inform their decisions.

### 7.3 DATA

In order to allow comparison of metal theft with other types of theft from the railway network, data on *all thefts* from the railway network were obtained from the publicly available [www.police.uk](http://www.police.uk) service provided by the Home Office. This service provides co-ordinates for all recorded crimes in England and Wales. Since May 2013, these records have been broken down into thirteen offence types. Between May and October 2013, there were 25,400 theft offences on the railway network, which were recorded as either robberies and personal thefts (24% of offences), thefts of bicycles (23%), thefts from shops (8%), thefts of and from motor vehicles (6%), burglaries (1%) or miscellaneous other thefts (38%).

In order to protect the anonymity of victims of crime, the Home Office does not release the precise co-ordinates at which offences occurred. Instead, before records are released their locations are changed to those of the nearest ‘snap point’, which is typically the centroid of the street on which the offence occurred. However, for offences at non-residential locations such as railway stations, no snapping takes place and actual locations are given (Ray et al.,

2012). As such, it was possible to allocate all theft records to a station Voronoi polyline to enable comparison between this and the live-metal-theft BTP data.

#### 7.4 ANNUAL PATTERNS OF LIVE-METAL THEFT

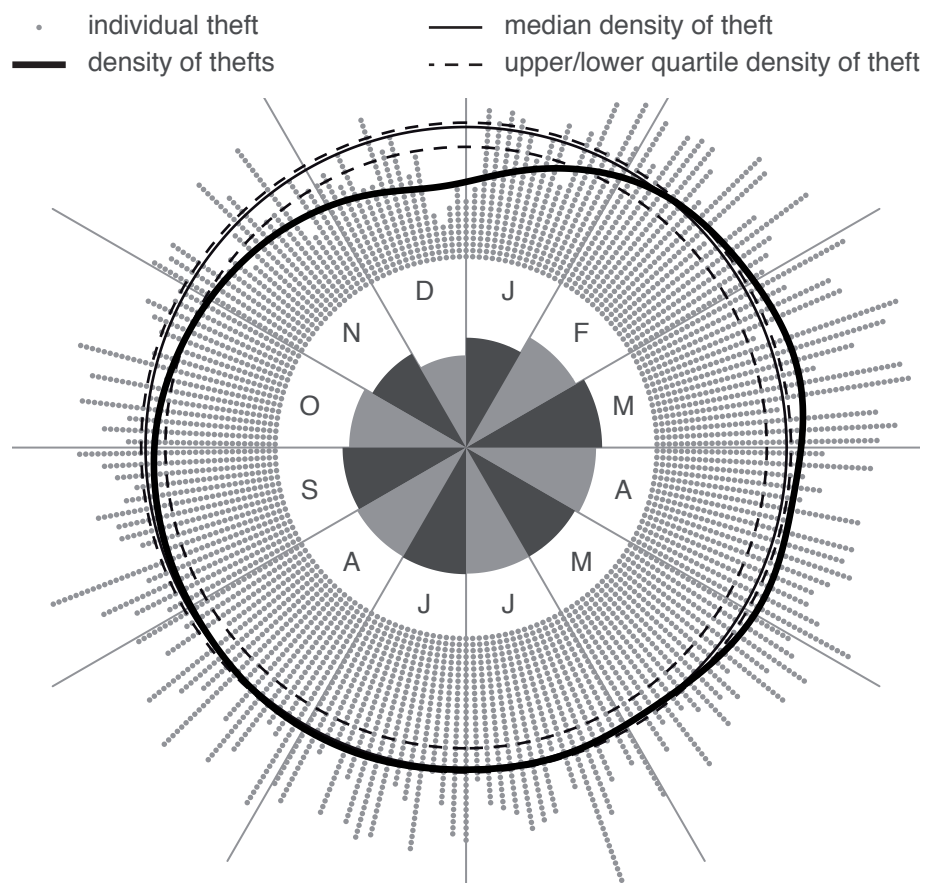
Many types of theft, such as burglary (Hird and Ruparel, 2007), thefts of and from motor vehicles (Andresen and Malleson, 2013), and street robbery (recently reviewed by Tompson and Bowers, 2013b), exhibit strong seasonal variation. A review by Baumer and Wright (1996) found that the frequency of many types of theft increases in the summer and decreases in the winter, although this is not universal – Yan (2004) found no evidence of seasonality in residential burglary in Hong Kong.

Figure 7.1 shows the occurrence of live-metal theft throughout the years 2007 to 2012. Temporal crime patterns are usually represented as if they are linear, but Felson and Poulsen (2003, p 597) demonstrated that doing so can obscure important systematic variation. Brunsdon and Corcoran (2006) recommended using circular statistics to overcome this problem, a recommendation followed here. The Rayleigh test of circular uniformity (Jammalamadaka and SenGupta, 2001, p 132) can be used to determine whether events are uniformly distributed throughout a cyclical period of time. This test showed that thefts do not occur uniformly throughout each year ( $\bar{r} = 0.145$ ,  $p < 0.001$ ). However, the Rayleigh test does not give any indication of the degree of non-uniformity over the year. Visual assessment of the histogram sectors and density curve (particularly in comparison with the median density) in Figure 7.1 suggests that the volume of thefts is similar from February to October (with a slight peak in March) and lower between November and January. The degree of seasonal variation appears to be less than that found for other crimes by, for example, Hird and Ruparel (2007, pp 5–6).

The most obvious seasonal trend evident in Figure 7.1 is the sharp decrease in crimes in the final two weeks of each year, when there were an average of 13 crimes each year compared to 32 crimes per fortnight during the rest of the year. Although completed research is limited, there is a widespread belief that much stolen metal is sold to SMDs. Since many SMDs do not trade between Christmas Eve and New Year's Day, thieves will not be able to sell stolen metal during that period. Previous research shows that shoplifters and

Figure 7.1: *Annual variation in theft of live metal from the British railway network, 2007–12.*

Dots represent individual crimes, stacked for reasons of space to show the frequency of crimes every two days. The thick line shows the density of offences, with bandwidth calculated to minimise error as determined by Hall et al. (1987, p 758). The area of each histogram sector shows the number of offences during each month.





burglars commonly dispose of goods very quickly (see Section 3.3). Rapid disposal of stolen goods both ensures that thieves benefit from the proceeds and minimises the risks of being caught with the goods, but it is not clear which of these factors (if either) plays a greater role in motivating metal thieves.

#### 7.5 SHORT-TERM PATTERNS OF LIVE-METAL THEFT

Between 2007 and 2012 there were a mean of 2.3 live-metal thefts each week from the British railway network. Theft occurred with approximately equal frequency on all days of the week except Sundays, when there were 30% fewer offences (Figure 7.2).

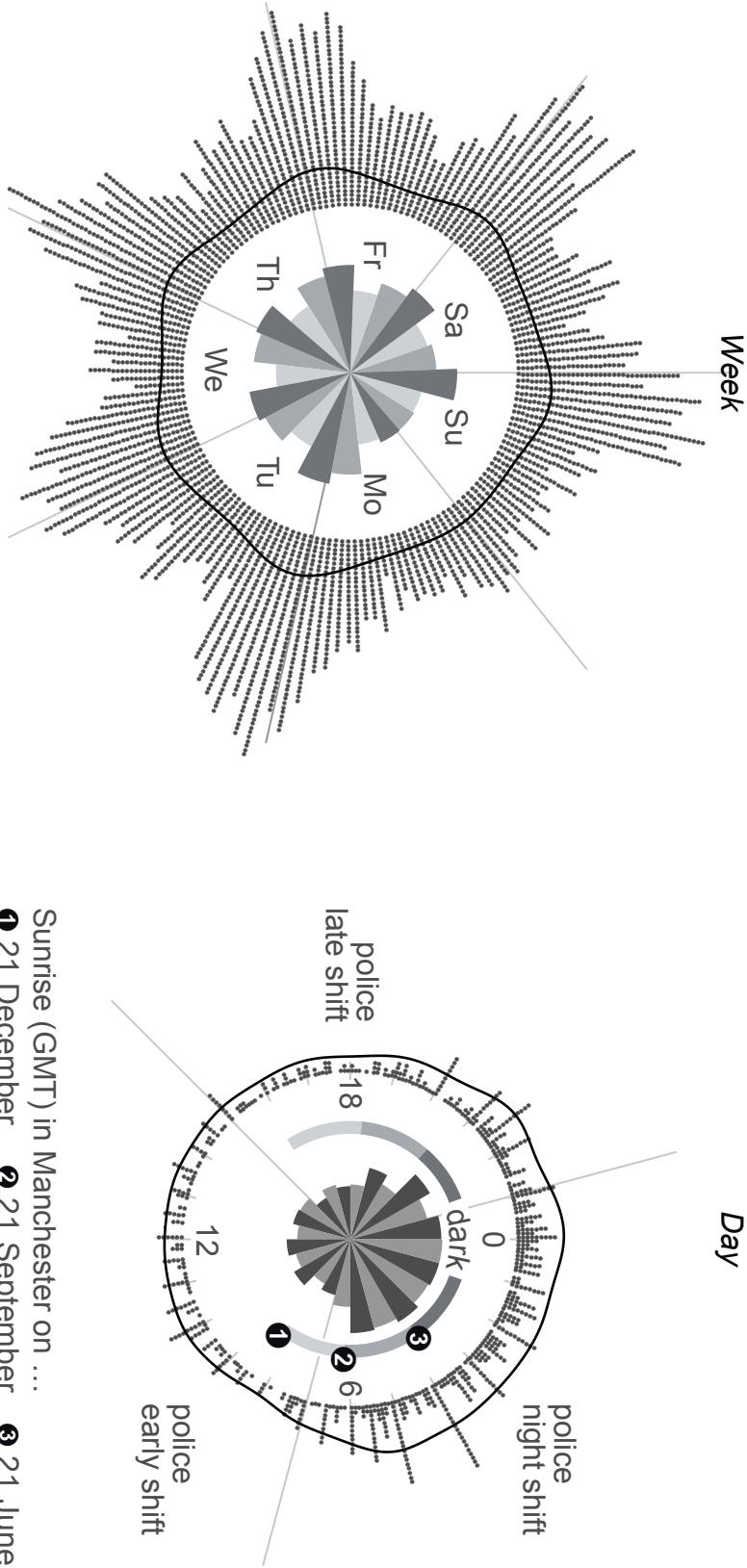
In common with many other types of theft (see Ashby and Bowers, 2012, for a review), many police records of metal theft do not include the exact time at which the offence occurred. Instead they specify a range of times between which the crime occurred. For the 38% of crimes with an apparent duration of over four hours, aoristic analysis (Ratcliffe and McCullagh, 1998) was used to estimate the most likely offence times. Aoristic analysis allocates fractions of crime counts to each period in which a particular crime could have occurred. The resulting aoristic value for each period can be interpreted as the estimated number of crimes that occurred during that period. Figure 7.2 shows that live-metal theft is a night-time crime: there is a peak overnight on every day except Sunday night/Monday morning, such that 46% of offences occurred between 2300 and 0700 hours.

The second panel of Figure 7.2 shows the daily pattern of offences. It was not possible to use aoristic analysis at this scale, because when crimes have a long duration it is common for police to record the range of potential offence times only to the nearest hour. As such and following the recommendation of Ratcliffe (2002, p 33), only offences with a duration of four hours or less were included. The peak offending times are between 2100 hours and 0600 hours, with the fewest offences occurring during the morning and evening commuting hours.

The relative frequency of metal thefts at night corresponds with a similar night-time peak in commercial burglaries found by Hakim and Shachmurove (1996, p 450). Imprisoned burglars interviewed by Butler (1994) emphasised the importance they placed on offending at times and places where the chance of being stopped by police was minimal. The same rationale may

Figure 7-2: *Variation in theft of live metal from the British railway network throughout the week and day, 2007–12.*

Dots outside the circular axis show offence times, black lines show the density of offences over time. The area of each sector in the central histogram shows the number of offences during each police shift (left) and hour (right). Offence times during the week (left) were determined aoristically (see text), while times during each day (right) are only shown for offences occurring in four hours or fewer.



Sunrise (GMT) in Manchester on ...  
1 21 December 2 21 September 3 21 June

explain the night-time peak in metal thefts. The frequency of train services on many lines is likely to make stealing live metal very difficult during peak hours. In contrast there are fewer trains in the late evening, when thefts are more common. While there are very few passenger trains between 0100 and 0500 hours, the absence of trains cannot wholly explain the overnight peak in offending. The true explanation may be the combined effect of the relative infrequency of trains after 2100 hours and the decreased risk of being observed during the hours of darkness.

The reason for the absence of an offending peak on Sunday nights is an open question. The author has raised this at several conferences in the search for a plausible explanation but as yet none has been forthcoming. One attendee at a conference in Atlanta suggested (apparently sincerely) that it might be because metal thieves are attending church on Sunday, but the author presumes that even the most devout worshiper would have left the last service before 2100 hours<sup>1</sup>.

## 7.6 REPEAT THEFTS

Repeat victimisations, which in the context of railway-metal thefts means repeated offences at the same location, have been recognised in the literature at least since Farrell and Pease (1993) found that repeat offences at a small number of locations or against the same victims accounted for a substantial proportion of all offences. Townsley et al. (2000) found that once a crime had occurred at a particular location, surrounding locations also had an increased risk of victimisation, at least temporarily (see Johnson, 2010a, for a review), known as ‘near-repeat’ victimisation. In the present research the aggregation of theft locations to the nearest station meant that it was not possible to differentiate repeat from near-repeat offences. In the following discussion the term ‘repeat’ should be taken to cover both repeat and near-repeat offences, which were analysed together.

Scholars have studied two potential mechanisms that might drive repeat victimisation, summarised by Pease (1998, p 8) as the ‘boost’ and ‘flag’ accounts. The boost account suggests that the increased risk stems mostly from the same offenders returning to places they have victimised before, while the flag account suggests that risk arises due to pre-existing features of

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<sup>1</sup> Without exception, when the author has relayed this story at subsequent conferences, at least one audience member has suggested that if metal thieves were to attend church it would probably be to steal lead from the roof.

the place. Recent research by Johnson (2008) has found that both phenomena are likely to play a role in combination.

Johnson et al. (2007) used Knox ratios (Knox, 1964) to quantify the difference between the number of offences observed at previously victimised locations relative to the expected number if being victimised once was associated with no additional risk of being victimised in future. Knox ratios can also be expressed as percentage changes in risk, where a ratio of 2 is equivalent to a 100% increase in risk compared to that expected if there was no repeat victimisation.

The period of which repeat-victimisation risk persists appears to vary by crime type. Johnson et al. (2007), studying repeat residential burglaries in five different countries, found that locations were at additional risk of victimisation for two weeks after a first burglary occurred there. A further study of residential burglary in two areas of the United Kingdom by Johnson et al. (2009) found an at-risk period of six weeks, as well as a period of two weeks for thefts from motor vehicles. Youstin et al. (2011) found that repeat-victimisation risk persisted for eight weeks for shootings, thefts of motor vehicles and street robberies in Jacksonville, Florida, although they do not state whether they tested for risk beyond this period. Also studying shootings, this time in Philadelphia, Ratcliffe and Rengert (2008) found an elevated risk for two weeks after an initial offence.

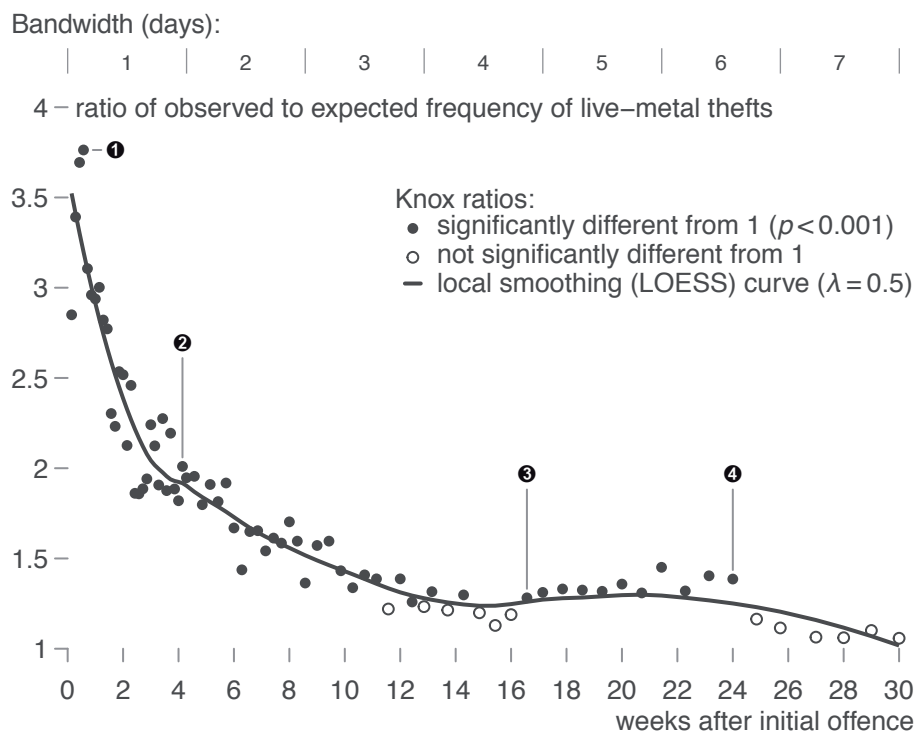
The near-repeat calculator (Ratcliffe, 2009) was used to calculate Knox ratios, along with  $p$  values determined using a Monte Carlo simulation with 1,000 iterations. This procedure compares the counts of crimes over different periods, and therefore requires the selection of a suitable temporal bandwidth. The near-repeat calculator can deal with a maximum of 30 temporal bands in one run, so to maximise the information returned the software was run with bandwidths from one to seven days, after which the most-detailed data were used for each time period.

Figure 7.3 shows the ratios produced by the near-repeat calculator, along with a non-parametric locally weighted scatterplot smoothing (LOESS) curve (Cleveland et al., 1992). The LOESS smoothing algorithm, which is analogous to other smoothing methods such as kernel-density estimation (Levine, 2013, 10.1), fits a local regression model to each part of the distribution, with the proportion included in each part represented by the parameter  $\lambda$ .

Following a live-metal theft at a particular location, a significant additional risk of a further offence occurring at the same location was found for three

Figure 7.3: *Repeat-victimisation risk in live-metal theft from the British railway network over time, 2007–12.*

Four days after the initial offence (❶), repeat offences at the same location are 3.8-times more likely than would be expected by chance. After four weeks (❷), repeat offences are twice as likely as would be expected by chance. A second, less intense, period of increased risk appears to start after four months (❸) and continue until five-and-a-half months after the initial offence (❹). Note that due to limitations in the Near Repeat Calculator, bandwidth is equal to one day for the first seven days, two days for the second seven days and so on.



months afterwards. The additional risk fell over time, so that half of the additional risk had dissipated within three weeks. Despite this reduction, repeat-victimisation risk then continued to be significantly greater than would be expected under the null hypothesis until at least 12 weeks after the initial offence. This is substantially longer than has been found in any other study of which the authors are aware.

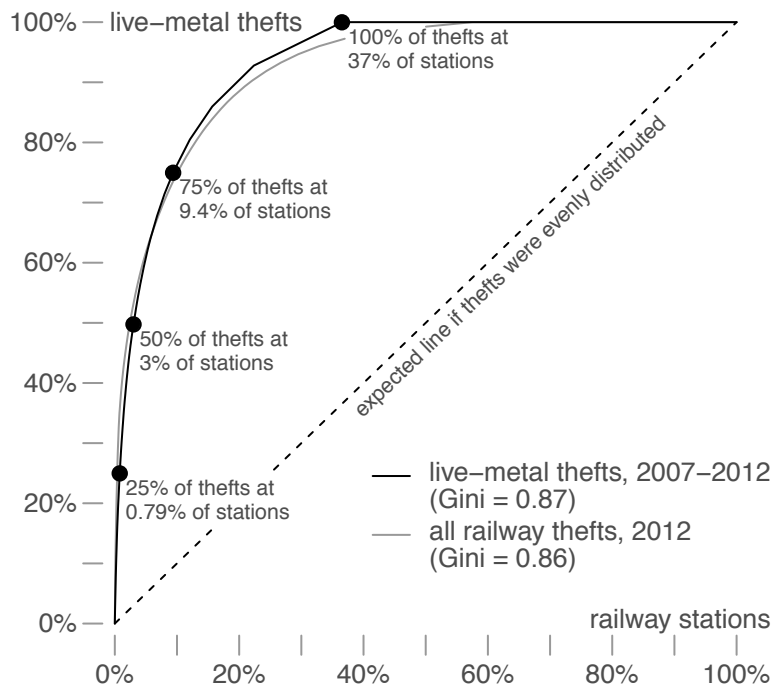
Johnson (2008, p 219), reviewing studies of repeat burglary from several countries, found that repeat-victimisation risk usually decays over time approximately according to an exponential function, with the greatest risk immediately after the initial offence. By contrast, the greatest repeat-victimisation risk of metal theft appears to be present four days after the initial offence rather than immediately afterwards. However, this maximum Knox ratio does not appear to be further from the smoothing line than several other points within the distribution, so it is difficult to come to any clear conclusions about the importance of this finding.

Unexpectedly, a second period of significant additional risk was found between 17 and 24 weeks after the initial offence. This could be a statistical artefact, created by a 'long tail' of marginally significant ratios, some above the critical value of  $p$  and some below. However, it could also suggest that offenders are more likely to return to an area after a certain period, perhaps because they believe that focused police patrols will have stopped or that the stolen metal will have been replaced. Without detailed information on patrol patterns or replacement schedules, it was not possible to test either of these hypotheses.

The presence of repeat-victimisation risk is important for policy makers because one common police response to a crime occurring is to increase patrols in the same area immediately afterwards. This tactic is predicated (at least in part) on the assumption that offenders are more likely to offend at the locations of previous offences than at a randomly chosen location. The results shown in Figure 7.3 suggest that in the case of live-metal theft from the railway network this assumption is met, and that hot spot patrols may be effective in reducing the number of offences occurring by reducing repeat victimisation.

Since the greatest risk of repeat victimisation is found in the first week after an initial offence, the procedure was repeated with a bandwidth of one day. This showed that the risk of another theft is 240% higher on the day after an offence, rising to 380% higher four days after an offence and then falling

Figure 7.4: *Spatial concentration of live-metal theft from the British railway network, 2007–12.*  
 Details of all railway thefts obtained from  
<http://data.police.uk/> for the calendar year 2012.



in line with Figure 7.3. This finding suggests that additional police patrols are likely to be most effective if they can be put in place quickly after a crime occurs. This requires an efficient mechanism for identifying where offences have occurred and communicating that information (and its importance) to patrolling officers.

#### 7.7 SPATIAL CONCENTRATION OF LIVE-METAL THEFT

In the present study, metal thefts were found to be strongly concentrated at a few locations: half of all metal thefts occurred at 3% of railway stations, while there were no metal thefts at 63% of stations. A similar concentration of crime has been found in other settings (for a review, see Weisburd et al., 2004, pp 287–8), with a similarly disproportionate amount of crime occurring at a few “risky facilities” (Eck et al., 2007).

Figure 7.4 shows a Lorenz curve (Lorenz, 1905) comparing live-metal thefts from the railway network with other types of theft from that network: thefts from shops in railway stations, burglaries of ticket offices, thefts of equipment

and thefts of and from cars in railway car parks. The similarity between the two curves is confirmed by the similar Gini co-efficients of 0.87 for live-metal theft and 0.86 for all railway thefts. Metal theft therefore appears to follow the “iron law of troublesome places” (Wilcox and Eck, 2011, p 476): a few places experience most offences, some experience the remaining offences and the majority of places experience no offences at all.

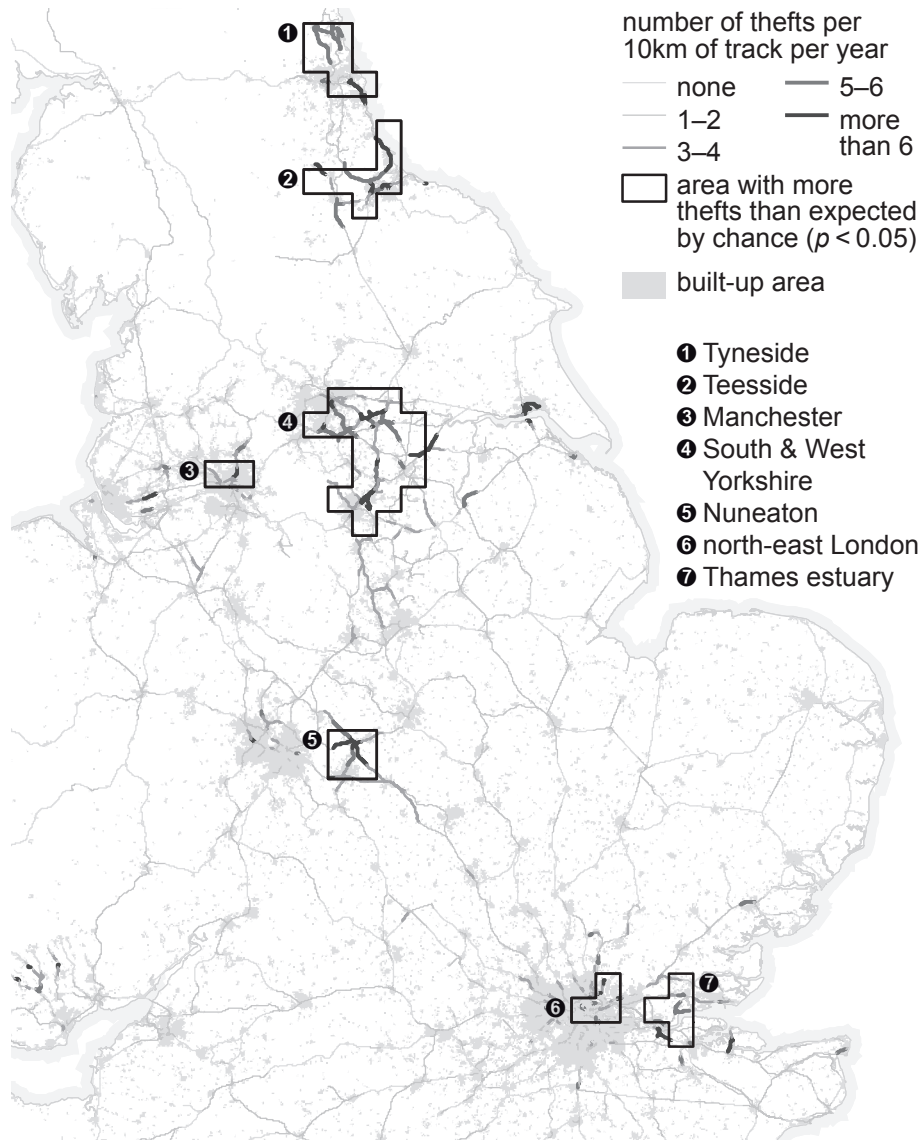
Figure 7.5 is a choropleth map showing the number of live-metal thefts per year per 10 km of track within the Voronoi polyline for each station. Choropleth maps have been largely replaced in the academic study of crime – see (Chainey et al., 2008) for a comparison of alternatives – but they may be the least-worst alternative when data are only available as counts of offences in areal units. Choropleth maps are problematic for two inter-related reasons. The first is that they do not show the precise locations of offences, but (as discussed above) this is an inevitable limitation of the present data and will not be considered further. The second is the modifiable areal unit problem (MAUP), description of which is usually credited to Openshaw and Taylor (1979) but dates at least to Yule and Kendall (1950, p 313). This describes how the results of spatial analyses can be strongly influenced by the choice of both study area and spatial units of analysis within that area, particularly when the chosen area and units are arbitrary. In the present research the study area was neither arbitrary nor modifiable, since it covers the entire railway network. The choice of the Voronoi polyline as the unit of analysis was modifiable, since another unit could have been chosen. Weisburd et al. (2012, p 23) argued that researchers should use the smallest spatial unit of analysis compatible with the precision of the underlying data. The Voronoi polyline was chosen with this axiom in mind, since the previously-described data limitations mean no smaller unit could be used.

Three observations are apparent from Figure 7.5: offences are clustered in a few hotspot locations, those hotspots are themselves clustered close to one another and hotspots tend to occur close to, but away from the centre of, cities.

It appears that there are large parts of the railway network in which metal theft is not a substantial problem. The significance of spatial clustering can be determined by comparing (using notation from Chainey and Ratcliffe, 2005) the mean observed distance ( $\bar{d}$ ) between each crime and the nearest crime to it with the expected mean distance ( $\bar{\delta}$ ) if crimes were distributed



Figure 7.5: *Map of live-metal theft from the British railway network, 2007–12.*  
 Hotspots were determined by calculating the  $G_i^*$  statistic (Getis and Ord, 1992). Data: Office for National Statistics, Ordnance Survey.



with complete spatial randomness (CSR). Expressed as a ratio  $\bar{d}/\bar{\delta}$  this is known as the nearest neighbour index (NNI).

Calculating the NNI is straight-forward for offences that occur in Euclidean space, but more complicated for those occurring on a network. Since metal thefts can only occur on railway lines, it was necessary to calculate  $\bar{\delta}$  by determining the mean distance between 5,044 points placed at random intervals along the railway network. Similarly, since many metal thefts were recorded as occurring at the nearest railway station to the place at which they actually occurred,  $\bar{d}$  was determined by placing points at random intervals within the Voronoi polyline associated with each station. As such, the calculated NNI represents a conservative estimate of the degree of spatial clustering, since it is likely that crimes were clustered within each station polyline. Since both were based on random distributions of points,  $\bar{d}$  and  $\bar{\delta}$  were each calculated 10 times and their mean values used to calculate an NNI of 0.65<sup>2</sup>. Following the procedure described by Clark and Evans (1954), a *z* score of 12.98 was calculated, confirming that metal thefts were significantly more clustered than would be expected by chance. While this result accords with findings in a great many other studies of crime, it is important for practitioners to remember that even an “epidemic” of metal theft (Milmo, 2008; Hough and Millward, 2011; Wright, 2011) can be restricted to a few parts of the country. This observation suggests that nationwide interventions may be less efficient than local problem-solving in hotspot areas.

The second observation from Figure 7.5 is the apparent clustering of hotspots close to one another, particularly in the middle of the UK. Such spatial autocorrelation has been previously observed for residential burglary (Bernasco and Luykx, 2003), street robbery (Bernasco and Block, 2011) and vehicle theft (Andresen, 2006). A Moran’s *I* test (Moran, 1950) can be used to determine whether observed spatial clustering of hotspots is significantly greater than would be expected under a null hypothesis that hotspots were distributed with CSR.  $I = 1$  indicates complete correlation,  $I = 0$  indicates CSR and  $I = -1$  indicates complete dispersion. The test requires aggregation of the study area into a grid. Following the procedure used by Marchione and Johnson (2013), Great Britain was divided into 10-kilometre squares, those squares through which no railway lines passed were removed and the number of metal thefts falling within each grid square was counted. As for the NNI test reported above, this procedure was repeated 10 times with crimes

<sup>2</sup> The coefficients of variation for  $\bar{d}$  and  $\bar{\delta}$  were less than 0.01, so 20 iterations were considered sufficient.

randomly positioned within each station Voronoi polyline. Since the  $I$  test compares the number of thefts in each cell with those in neighbouring cells, the user is required to specify which cells should be treated as neighbouring the cell being tested. In this case, following Ratcliffe (2010b, p 25), cells were treated as neighbouring if their outlines touched one another at any point. The mean result of this procedure was  $I = 0.61$  ( $p < 0.001$ ). Since this value was positive, the observed hotspots were more clustered than would be expected under CSR and so confirmed that hotspots were themselves clustered close to one another<sup>3</sup>.

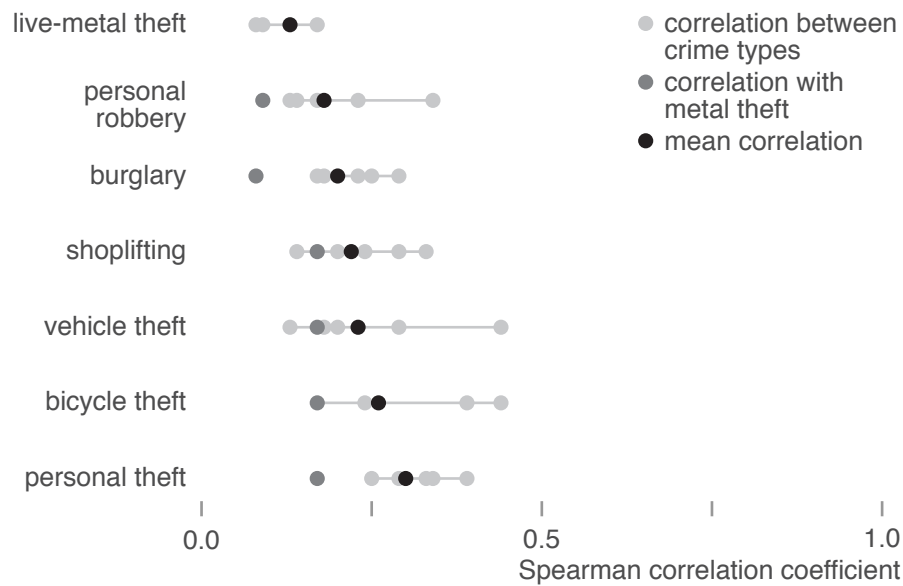
Although the global statistics used in this case appear to be robust, they provide no information about local spatial variation in live-metal thefts. Anselin (1995) described a number of statistics for the study of local variation of spatial phenomena under the name local indicators of spatial association (LISA). Of those, the pre-existing  $G_i^*$  statistic (Getis and Ord, 1992) has become perhaps the most well-used in crime analysis (e.g. by Mencken and Barnett, 1999; Ratcliffe and McCullagh, 1999; Ceccato et al., 2002a; Siebeneck et al., 2009). The  $G_i^*$  test determines whether or not each cell in a grid is “the centre of a group [i.e. hotspot] of unusually high values centred on [that cell] and its surrounding cells” (Chainey and Ratcliffe, 2005, p 165), where “unusual” is determined by calculating the probability of that number of crimes occurring by chance, expressed as a  $z$  score. Since this involves multiple comparisons between cells, the probability required before a hotspot can be considered significant must be adjusted. This was done using an equation proposed by Ord and Getis (1995, p 297) that determined the required critical probability  $\alpha_m$  from the number of cells  $n$  and the critical probability  $\alpha$  that would be used for a single comparison:

$$\alpha_m = 1 - (1 - \alpha)^{1/(n-1)}$$

3 The NNI and Moran’s  $I$  are subject to various limitations, as described by Unwin (1996). The problem of edge effects (Ratcliffe, 2005) could not occur in the present research because the study area included all of the railway network. Two more-important limitations are the assumption of stationarity and the MAUP.

The NNI calculated here is not subject to the MAUP, since the study area included the entire railway network. However, the 10 km cells for calculating Moran’s  $I$  are modifiable and both Jelinski and Wu (1996) and Marchione and Johnson (2013) found that Moran’s  $I$  values varied according to the grid chosen. To check the value of  $I$  produced above, the test was repeated with the cell size increased in 1 km increments from 5 km to 15 km. The resulting values of  $I$  varied from 0.53 to 0.66, with a mean of  $I = 0.61$ . These values suggest that live-metal thefts are clustered in space regardless of the effects of the MAUP.

Recent studies of spatio-temporal variation in crime have concluded that the distribution of crime is often not stationary, such that spatio-temporal analysis (see below) is likely to be more illuminating than global measures of spatial concentration.

Figure 7.6: *Spatial correlation of different types of railway thefts, 2012.*

In the present case,  $\alpha = 0.05$  and  $n = 1,253$  giving  $\alpha_m = 4.09 \times 10^{-5}$ , for which  $z = 3.989$ .

Those grid cells with  $z > 3.989$  are highlighted on Figure 7.5. There are seven statistically significant hotspots, all in England, which together contain 38% of all live-metal thefts reported to BTP between 2007 and 2012. The hotspots vary substantially in size and volume of crime: three (in Manchester, north-east London and the Thames estuary) had fewer than two crimes per month on average, while the hotspot covering South and West Yorkshire experienced 12 crimes per month over the same period.

To determine whether the locations of live-metal theft hotspots shown in Figure 7.5 were typical of railway thefts more generally, the number thefts of each type in the subsidiary dataset (from [www.police.uk](http://www.police.uk)) was counted for each Voronoi polyline. Bivariate Spearman rank correlation coefficients were then calculated for pairwise comparison of the spatial concentration of live-metal theft with the concentration of each of the other theft types. A Kruskal–Wallis rank sum test showed that the distributions of the correlation coefficients for different crime types varied significantly from one another ( $\chi^2 = 12.66$ ,  $p < 0.05$ ). Figure 7.6 shows that metal theft has the weakest correlation with other types of theft. This suggests that metal theft clusters in different places to other railway crimes. This finding may be valuable to practitioners because it suggests that police deployment patterns, shaped by

exposure to long-standing crime problems such as personal robbery, may be inefficient in tackling an emerging crime problem such as metal theft. As such, new patrol patterns will be required to counter this new threat to security.

Previous studies of other types of theft (e.g. Rengert, 1997; Ratcliffe, 2002) have found that the temporal concentration of a single type of crime often varies across hotspots. To examine this phenomenon in relation to live-metal theft, temporal patterns were examined for those hotspots with more than two crimes per month on average, as shown in Figure 7.7. Since temporal variation can be multidimensional, three views of the data are shown. The difference between the long-term trend in thefts at each hotspot and the trend outside the hotspots can be summarised using a Spearman rank correlation coefficient ( $\rho$ ). All of the hotspots had trends different from those outside the hotspots, with values of  $\rho$  between 0.28 and 0.62, suggesting imperfect correlations.

Testing for differences in the distribution of thefts throughout the year or the week required a test suitable for non-parametric circular data. Fisher (1993, p 123) recommended the Wheeler and Watson (1964) test ( $W_r$ ), which determines if two samples of circular data are identically distributed. The annual distribution of thefts at each hotspot was compared to the distribution of thefts outside hotspots. Only the Nuneaton hotspot had a distribution significantly different from that outside hotspots ( $W_r = 0.56$ ,  $p < 0.001$ ). This can be seen in Figure 7.7, which shows thefts around Nuneaton to be concentrated in the early months of the year. The Wheeler–Watson test was also applied to the weekly variation in thefts. This showed that weekly variation at Nuneaton ( $W_r = 0.29$ ,  $p < 0.01$ ) and Teesside ( $W_r = 0.28$ ,  $p < 0.01$ ) were significantly different from that outside hotspots.

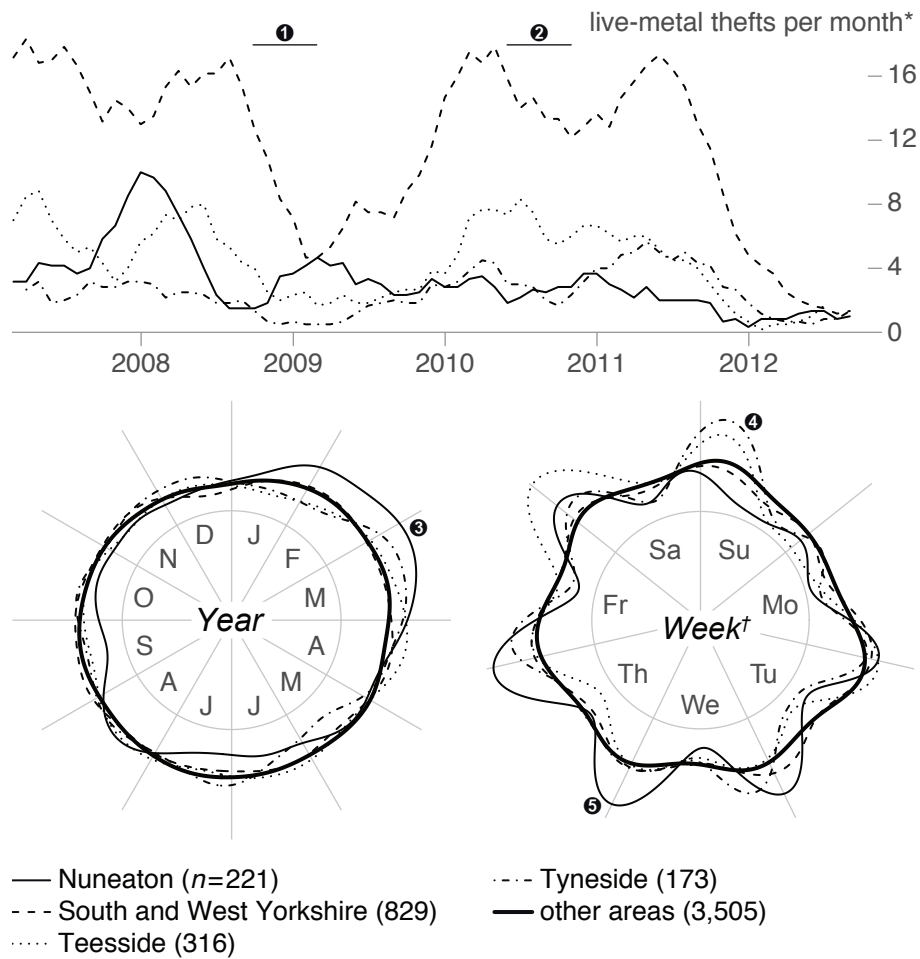
## 7.8 DO METAL THIEVES PLAN THEIR OFFENDING?

Very little is known about the nature of metal theft offences. Until more is known, it may be beneficial to draw limited inferences about offences from their spatio-temporal characteristics.

One question about the nature of offences that has received only limited treatment in criminological literature is the degree to which offenders plan their offences. Most modern research on spatio-temporal variation in the occurrence of crime is based on opportunity theories developed from the

Figure 7.7: *Temporal variation in live-metal theft from hotspots on the British railway network, 2007–12.*

There appear to be differences between the temporal distribution of metal thefts at different hotspots. In particular, the number of thefts around Nuneaton went up (❶ and ❷) while the frequency was decreasing elsewhere. Theft around Nuneaton are also more concentrated during the year than theft elsewhere (❸). In Teesside and Tyneside, thefts are more common on Saturday nights (❹), while thefts in Nuneaton occurred on weekday evenings (❺).



routine activities approach of Cohen and Felson (1979). Within this paradigm “criminal events are reactions to local opportunities as they occur” (Herbert and Hyde, 1985, p 260), leaving open the question of the degree to which offenders will plan their offences, given that they have identified or anticipated an opportunity to offend. Offender decision-making research has found that the extent of offence planning varies widely, with “opportunistic amateurs, journeymen who search for targets, and professionals who carefully plan their offences” (Brantingham and Brantingham, 1990, p 26).

There is reason to think that the temporal patterns of live-metal theft discussed above suggest that offenders plan more than is typical of acquisitive criminals in general. Figure 3.2 and the results presented by Sidebottom et al. (2011) show a clear link between metal price and the frequency of metal theft. The direction of causality (if any) in this link has not been confirmed, but Sidebottom et al. (2014) ruled out influence by other variables such as unemployment and it appears unlikely that there is enough metal stolen to influence the wholesale price. If changes in prices do drive changes in the frequency of thefts, the most likely mechanism appears to be that offenders are reacting to price changes, suggesting a degree of forward planning about when to offend.

The relative lack of seasonal variation, in contrast to the strong seasonality usually found in the studies of acquisitive crime mentioned above, suggests that metal thieves are often willing to offend regardless of those factors such as weather that have commonly been found to drive seasonality. The apparent resilience of metal thieves in this regard again suggests greater planning than is typical in much acquisitive crime.

As noted above, Figure 7.5 shows that metal thefts appear to concentrate close to, but not in the centre of, cities. This is atypical of other types of theft, which tend to be concentrated in urban areas (Aust and Simmons, 2002). One reason for the typical urban concentration is that thieves tend to live in cities and to commit most of their offences close to where they live (Wiles and Costello, 2000; Bernasco and Nieuwbeerta, 2005), either as a result of offenders’ wish to minimise the effort of offending (Bernasco and Block, 2009, p 97) or because offenders will only be aware of targets within their awareness space (Brantingham and Brantingham, 1993, p 10). While many theft targets such as houses, shops and banks are more concentrated in urban areas, urban railway lines tend to be well-protected by fences to stop trespassing. The concentration of thefts close to cities may suggest that urban

offenders are travelling to the closest rural railway line of which they are aware in order to offend. If true, this in turn would suggest that railway-metal thieves are likely to have either a large awareness space or be planning the location of offences in advance, at least in broad terms, by pre-selecting target locations. It also suggests they need access to vehicles, which in any case would be required in order to remove metal from the railway: 100 metres of copper signalling cable can have a mass of up to 200 kilograms (Unipart Rail, 2009, p 12). Vehicles must either be purchased – which requires funds – or stolen – which requires particular skills and has become much more difficult in recent years (Farrell et al., 2011, p 153), again suggesting at least a certain level of offence planning.

The concentration of metal theft in the early hours of the morning contrasts with other types of transport theft, which Ceccato and Uittenbogaard (2014, p 139) found tended to concentrate at times and places when and where transport networks were busiest, i.e. when there were most potential offenders present. If railway-metal theft were an opportunistic crime, it would be expected that offences would peak at busy stations at busy times. The opposite appears to be true: offenders appear not to prefer busy places and seem to wait until after midnight, when offending is aided by darkness and lack of guardianship. In this respect, metal thefts appear to be similar to robberies of transport passengers, which Clarke et al. (1996) found clustered at stations with fewer passengers. This may explain why the spatial correlation (Figure 7.6) between metal theft and other types of railway theft is lower than between those other types: those committing other types of theft (except for commercial burglaries) require the presence of a person's property to steal, while for metal theft the presence of other people may be a deterrent.

More certain and more detailed results on the extent to which metal thieves plan their offending could be obtained using alternative methods such as offender interviews or analysis of offending histories. In the absence of such research, it appears that the theft of metal from the railway network is likely to be a planned offence rather than a highly opportunistic one. This conclusion could have implications for crime prevention because it suggests that railway-metal theft is committed by a relatively small number of repeat offenders each committing a relatively large number of crimes. Eck (2001, p 252) argued that such repeat-offender crime problems can be effectively tackled by focusing on preventing those offenders from stealing in future. An offender-focused approach would also deal with a potential problem raised



by Short et al. (2010), who hypothesised (based on a theoretical mathematical model) that crime hotspots resulting from the activities of planned offenders were more likely to experience spatial displacement of crime as a result of police activities to eliminate the hotspot.

## 7.9 CONCLUSION

The research presented here paints a detailed picture of metal theft from the railway network of Great Britain. The spatial and temporal patterns of metal theft appear to be different from those established for acquisitive crime in general. Metal thefts occur throughout the year at approximately the same rate, in contrast to most acquisitive crimes which show strong seasonality. Metal thefts appear to be concentrated in different places to other types of theft, particularly in rural areas close to cities, rather than in cities themselves. Once a metal theft has occurred at a particular location, that place appears to be at additional risk of being victimised again for much longer than has been found for other types of crime.

One reason for this is that railway-metal thefts appear to be committed by offenders who plan rather than by opportunists. It seems reasonable to hypothesise, in the absence of direct evidence, that such offenders would be more responsive to changing prices, more resilient to the changing seasons, more willing to travel long distances and more likely to return to previous offence locations. In all these ways, railway-metal theft was found to differ from other types of acquisitive crime. This planning hypothesis could be tested in future research, for example by interviewing offenders, although this may be difficult because offenders who plan may be less likely to be caught, introducing sampling bias into any such study.

A second reason for the unusual patterns found in metal theft may be the role of SMDs in the disposal of stolen goods; the only weeks of the year and days of the week on which there were substantially fewer metal thefts co-incided with those days on which many SMDs are closed. Further research would clarify this relationship, which is particularly important because many governments have increased the regulation of SMDs in response to the increased frequency of metal theft since 2007. This is the subject of the next chapter.







## METAL THEFT AND SCRAP-METAL DEALERS

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### SUMMARY

- Efforts to prevent metal theft have often focused on the role of SMDs as potential handlers of stolen metal, but little evidence is available to support this relationship.
- This chapter tested for a spatial association between the locations of SMDs and concentrations of metal theft.
- Metal thefts were found to be significantly more common from parts of the railway network that are closer to more SMDs.
- This relationship exists even when the local density of population, industry and availability of metal from the railway network are taken into account.
- This supports the MRA and the influence of land-use on crime predicted by the routine-activities approach, but not the hypothesis discussed in the literature that such influence is dependant solely on increases in ambient population associated with some types of land use.

## 8.1 INTRODUCTION

The crime script presented in Chapter 6 suggested that fences are likely to have a key role in metal theft because thieves only realise any benefit from their crime at the point that they can sell-on the stolen metal. The apparent importance of fences has not escaped the notice of policy makers, and so there has been considerable practitioner focus on attempting to make it harder to fence stolen metal. Since the most obvious *potential* fences for stolen metal are scrap-metal dealers (SMDs), this focus has largely involved increasing monitoring and regulation of such sites. As of mid-2014, laws to regulate SMDs exist in all 50 US states and in at least 14 EU countries (Institute of Scrap Recycling Industries, 2014). Measures introduced include a ban on paying cash for scrap metal, waiting periods for payment, waiting periods for the reselling of metal by an SMD after purchase, increased record keeping, notification of sales to local government and restriction or prohibition of trading in certain types of metal (such as drain covers) that are particularly vulnerable to theft (for a survey of different measures, see Waterfield and Short, 2014). Additionally, some countries that have not previously regulated SMDs are now considering doing so (Agenfor, 2011, p 18).

Although enhanced regulation of SMDs has become commonplace, at the present time there is little evidence that applying the market reduction approach (MRA) to them will help prevent metal theft. This lack of evidence is partly due to the difficulty of measuring the involvement of SMDs in metal theft, and partly due to the new regulations having only been recently introduced. Given these difficulties, the present chapter reports research that tested for a link between the locations of metal thefts and those of SMDs.

To set the context for this chapter, the following section will provide a brief description of the scrap-metal industry as it operates in most countries. This will be followed by an overview of existing work on stolen-goods markets in general and then with specific reference to SMDs.

## 8.2 THE MARKET REDUCTION APPROACH TO CRIME PREVENTION

The idea that thefts can be prevented by reducing societal demand for stolen goods is not a new one – it was considered old even in the 1790s (Colquhoun, 1797, p 173). Many scholars have made the suggestion, including Chappell and Walsh (1974b), Sheley and Bailey (1985) and Freiberg (1997). The general hypothesis is that, since offenders generally steal in order to make money by selling the proceeds of the theft, if it is harder to sell stolen goods then there will be less incentive for people to steal goods in the first place. As such, this is a form of SCP (see Section 2.6.5), designed to reduce or eliminate the “situational cue” to offending that potential offenders receive from an environment in which converting stolen goods is easy (Cornish and Clarke, 2003).

This method of crime prevention was expanded upon by Sutton (1995), who later referred to it as the MRA (Sutton, 1998). The MRA seeks to:

“(1) Instil an appreciation among thieves that selling, transporting and storing stolen goods has become at least as risky as it is to steal the goods in the first place [and] (2) make buying, dealing and consuming stolen goods appreciably more risky for all those involved” (Sutton et al., 2001, p 5).

The MRA seeks to change the behaviour of both thieves and those who buy from them by changing their environment in order to convince them that the risks of offending are high. A key feature of the MRA is the contention that there is not one market for stolen goods but many small, fragmented markets (Sutton, 1998, p 66). Since different people are involved in each, different responses are likely to be required to counter different markets (Sutton et al., 2001, p 5). This accords with findings elsewhere in the SCP literature that crime prevention initiatives work best when they are tightly focused on very specific crime problems (see Section 2.4.3). The potential for different types of stolen-goods market to operate in relation to a specific type of stolen goods is illustrated in unit E of the crime script shown in Figure 6.6.

Like other types of SCP, the MRA is based on the rational-choice theory of offender behaviour (see Section 2.4). In the context of thieves disposing of stolen goods, the rational-choice approach suggests that thieves will seek to dispose of goods in such a way as to maximise their profits and minimise the risk of apprehension. Since offenders make decisions under bounded rationality (Clarke and Cornish, 1985), those decisions may be subject to manipulation as a result of market-reduction measures put in place to reduce theft.

Although it appears obvious that thieves would be more likely to steal items if it is easier to sell them on, there has been surprisingly little empirical research testing the effectiveness of the MRA. Albers-Miller (1999) studied the factors that determined consumers' willingness to buy stolen goods and found that survey respondents were more willing to buy stolen goods when prices were lower, but that the perceived risk of criminal punishment had no influence on willingness to buy. This supported earlier findings by Sheley and Bailey (1985, p 407) that the potential buyer's perception of the likelihood of criminal sanction was not associated with their willingness to buy stolen goods.

Hale et al. (2004) reported the results of two direct trials of the MRA in the UK, neither of which found any significant reduction in residential burglary in the trial areas compared to surrounding police districts. However, those authors noted that it was very difficult to separate those crimes associated with different stolen-goods markets, so it was possible that a positive effect in one market was not discernible in the aggregate burglary statistics. Schneider (2004) interviewed burglars in an area before and after an application of the MRA that targeted neighbourhood fences. After the intervention, some of the burglars who had used those fences appeared to shift to instead sell stolen goods through their own networks of friends. Fass and Francis (2004) argued that the MRA is likely to be ineffective when goods were being fenced through pawn shops, since interviews with thieves showed measures such as requiring identification were ineffective.

A recent study by Mares and Blackburn (2014) reported the results of a natural experiment of the MRA in the context of metal theft. The city of St Louis enacted a law prohibiting SMDs from paying cash for scrap, as well as restricting the purchase of certain high-risk metal items and introducing purchase records. By studying the volume of metal thefts reported to the police before and after the law was introduced, they found that the frequency

of metal theft decreased when the law was introduced, compared to the frequency of other thefts.

### 8.3 THE SCRAP-METAL INDUSTRY

Section 3.3 described why metal is often a CRAVED object for offenders, but exploring the relationship between metal theft and SMDs requires an understanding of the wider market for scrap metal. Since metals can be melted down, they are inherently re-usable and have always been recycled (Vogler, 1985, p 1). Metal recycling has economic benefits for society (Medina, 2001, p 237; Fletcher, 1976, p 151) and also social ones: recycling reduces both the high energy-use and substantial environmental impact of mining metal ores (Ayres, 1997; Frosch et al., 1997, p 1339). Every tonne of copper recycled, for example, avoids the production of approximately 200 tonnes of waste required to produce the same mass of metal from ore (Spoel, 1990, p 38). However, not all metal can be recycled, for example copper powder used in pesticides and zinc powder in paints (Ayres, 1997, p 147). Global demand for copper increased by 29% between 2000 and 2011, particularly in Asia (CRU Strategies, 2013, p 36). Most of that demand came from China – which by 2011 consumed 40% of the copper available for sale – while demand in Europe and North America fell in the same period (CRU Strategies, 2013, p 36). In 2013, the UK exported scrap copper with a value of £31 million to China every month – 82% of all scrap copper exports (HM Revenue and Customs, 2014). Constraints on the supply of copper ore led to a 45% increase in the mass of scrap-copper consumed between 2003 and 2011, such that most refined copper is now produced from scrap rather than ore (CRU Strategies, 2013, pp 41–2).

SMDs act as a link between generators and users of scrap metal. Scrap metal can be classified as ‘new’ scrap, the by-products of industrial and manufacturing processes (such as off-cuts from the production of car doors), and ‘old’ scrap, material that is recovered as an alternative to being disposed of. The volume of copper old scrap is approximately five times that of copper new scrap (Spatari et al., 2002, p 27) and most metal theft is of old scrap, so new scrap will not be discussed further.

Old scrap often exists in very small quantities – for example a car being disposed of by its owner or copper piping from a house being renovated – which SMDs must aggregate. The fragmented supply of old scrap has

led to the scrap-metal industry itself being fragmented, with many smaller SMDs passing metal onto ever-larger SMDs until enough metal has been aggregated to enable it to be processed, melted down and re-used (Fletcher, 1976, p 153). The smallest participants in the scrap-metal industry are itinerant collectors who travel around buying scrap from any available source or simply collecting dumped metal from road sides and wasteland (Sibley, 1976; Gmelch, 1986). Traveller and other nomadic groups have often been important participants in the scrap-metal industry at this level (Sibley, 1976; Gmelch, 1986, p 312), but itinerant collectors also include homeless people, the very poor and new migrants (Medina, 2001, p 231). In developing countries in particular, itinerant collectors are an important part of waste-management systems (Rogerson, 2001; Li, 2002). Such collectors commonly sell the metal they collect to local SMDs, who also buy scrap from individuals and local businesses. Local SMDs typically negotiate prices on the spot without an existing contract (Office of Fair Trading, 2014).

Local SMDs can sell metal either to a metal foundry or (more often) to a larger SMD who can aggregate enough scrap to economically process it into forms that can either be re-used or sold to a foundry for melting down (Clapp, 1994, p 211). Some large SMDs are substantial multi-national operations: for example the largest UK SMD is also the tenth largest privately-owned business in the country, with over £3 billion in sales in 2012 (Tyler and Marshall, 2014, p 24). Such companies buy old scrap from smaller dealers, but also have long-term contracts to process prompt scrap from manufacturing companies and old scrap from local authorities and other waste-processing companies.

The structure of the scrap-recycling industry has two potentially important consequences for the involvement of SMDs in handling stolen goods: outside of large contracts, transactions are largely conducted in cash and the dealer will often have no previous knowledge of the seller. This makes SMDs – particularly local dealers – vulnerable to being employed as handlers of stolen goods, even if they attempt not to be.

#### 8.4 STOLEN GOODS MARKETS

A large majority of goods that are stolen are subsequently sold-on rather than kept for use by the thief (Walsh and Chappell, 1974, p 117), suggesting a central role for the fence in the act of stealing. Walsh and Chappell (1974,



p 115) presented a conceptual model of a “stolen goods system” describing how thieves plan and execute a theft before transporting the goods to a potential end-user and arranging their sale. For many types of theft, it is possible for the thief to carry out every step alone, described as “self fencing” by McIntosh (1976, p 257). However, self fencing – typified by the thief selling stolen watches from inside his jacket (Chappell and Walsh, 1974a, p 168) or stolen meat in pubs and bars (Cromwell et al., 1993, p 81) – is not possible for all types of theft: one thief interviewed by Walsh and Chappell (1974, p 117) reported there was no benefit to stealing particular precious stones unless he was able to sell them to one specific fence.

It appears that the majority of thieves choose not to self fence, and instead sell their stolen goods to a receiver. Several scholars (for example Hall, 1952; Blakey and Goldsmith, 1976; Cromwell et al., 1993; Wright and Decker, 1994) have proposed typologies of fences, recently reviewed by Sutton (2014). The typology used by Wright and Decker (1994) is typical, in dividing fences into professionals, pawn brokers, drug dealers and friends or relatives of the thief. Whatever the specific categories used, it is clear that different thieves use different types of fence, depending largely upon the level of organisation involved in the theft (Wright and Decker, 1994, p 167; Sutton, 1995, p 404). Professional burglars, stealing high-value goods for specific markets, are far more likely to use a professional fence (Wright and Decker, 1994, p 167). A drug addict stealing anything available in order to buy drugs would be far more likely to simply trade the goods for drugs (Sutton, 1995, p 404). Wherever a thief chooses to sell stolen goods, it will be for cash or other property: none of the thieves interviewed by Roselius and Benton (1973, p 186) were willing to offer credit.

#### 8.4.1 *SMDs and stolen goods*

From the description of the scrap-metal market above, it is apparent that (notwithstanding the legality of – and social benefit from – scrap-metal dealing) there are notable similarities with stolen goods markets. Both are based largely on cash payments with prices agreed at the time of sale rather than by prior contract. Buyers (be they fences or SMDs) typically have little or no prior knowledge of sellers and therefore little knowledge of the provenance of the goods on offer. Both are also fragmented, with many

small businesses offering to buy goods from an even larger number of small suppliers.

None of this is to suggest that SMDs are criminals; they are typically working hard at a business that has very low profit margins (Krajick, 1997, p 42) that in many countries is seen as unpleasant or of low social status (Zimring, 2004). SMDs can also be victims of metal theft. The similarities between the two markets, however, make SMDs vulnerable to exploitation by criminals. This is not a new problem: a US court judgement from 1930 described the industry as

“a legitimate business, meeting a public demand, but it is the history of experience that it is sometimes conducted in a dubious fashion and becomes a place where thieves turn into cash their ill-gotten plunder. It is, perhaps more often, an innocent receiver of contraband” (Zimring, 2004, p 90).

Nevertheless, some SMDs are actively and knowingly involved in handling stolen goods. Medina (2001, p 235) found that some SMDs in New York City were known to wait nearby while thieves stole metal, in order to be able to purchase it immediately; Pretorius (2012, pp 41, 49) reported several cases of active SMD involvement in metal theft in South Africa. Legitimate SMDs can also have their business undermined by nearby competitors who knowingly accept stolen goods.

A similar situation exists with pawn brokers, who have been found to be common – but often unwitting – recipients of stolen goods (McIntosh, 1976, p 257, Wright and Decker, 1994, p 174, Stevenson et al., 2001, p 102). In both cases, the dealer must accept a wide variety of goods from a wide variety of sources, and only have limited means with which to check that those goods are not stolen. This is particularly true for SMDs, since with many types of metal (for example bare copper wire) it is impossible to distinguish one batch from another (Spendlove, 1961, p 3). Even if SMDs were not particularly vulnerable, previous research (Cromwell and McElrath, 1994, p 302; Sutton et al., 1998, p 8) has shown that it is common for innocent people to be offered stolen goods, and that many companies buy stolen goods that are relevant to their legitimate business (Cromwell et al., 1993, p 86). There may be reason to believe that SMDs are even more vulnerable to being offered stolen goods than pawn brokers are: Wright and Decker (1994, p 175) found that some thieves avoid selling to pawn brokers because police often visit pawn shops looking for stolen goods, but metal thieves may have little alternative but

to offer the goods to an SMD (Price et al., 2014). Except in the (presumably unusual) circumstance of a thief being able to melt-down old scrap and resell it as new, the only alternative to selling it to an SMD locally would be to export it directly to an SMD in another country<sup>1</sup>.

When SMDs are involved in handling stolen metal, that involvement is likely to mirror the division of other stolen goods markets between different types of theft. The involvement of itinerant collectors in metal theft is a long-standing problem, with accounts in the literature from the 19th Century onwards (Hunter, 1919, p 168; Zimring, 2004, p 90). Nevertheless, the bulk of handling of stolen metal is likely to be done by local SMDs: they are most vulnerable to attempts to sell them stolen metal disguised as legitimate scrap, are often exposed to the widest variety of customers, and many itinerant collectors sell metal on to them. In contrast, large SMDs who mainly undertake contract work may well be less involved.

The only study to provide evidence on the involvement of SMDs in handling stolen metal is that by Whiteacre and Howes (2009). They compared the number of metal-theft insurance claims with the number of SMDs (both normalised per 100,000 population) in the 51 US cities with the highest number of such claims. To account for alternative explanations of any correlation, the model controlled for the rate of burglaries and the payroll of manufacturing businesses in those cities. Both the number of SMDs and the burglary rate were found to be significant predictors of the frequency of metal-theft insurance claims in a city.

As the only previous study of its kind, the work reported by Whiteacre and Howes (2009) provides a valuable insight into the relationship between SMDs and metal theft. However, due to the paucity of available data on metal theft at the time, the study has some limitations. Lists of SMDs were obtained from telephone directories, which include only those businesses that pay to advertise in them. This may be particularly problematic in a fragmented industry such as scrap-metal dealing. Records of metal thefts were obtained from National Insurance Crime Bureau (NICB), and so will only include thefts of property that was insured and for which a claim was made. This may be problematic because many large users of metal such as railways and utility companies may find it less expensive to self-insure against metal theft, meaning thefts against them will not be recorded by NICB (Burnett et al.,

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<sup>1</sup> Conversations with police officers dealing with metal theft suggest that such exports do occur, but little is known about them and they are outside the scope of the present study.

2014). Studying only those cities with the highest frequency of metal theft may also limit the generalisability of their results.

Whiteacre and Howes (2009) were only able to consider correlations at the city level. Given that intra-city variations in the relationship between SMDs and metal theft could not be explored, it may be that the results reported include an element of aggregation bias due to the modelling of the decision-making of individual thieves and fences at the aggregate level. Clark and Avery (1976) showed that regression models using aggregate spatial data were likely to result in inflated correlation coefficients, and that these issues can be minimised by using smaller spatial units of analysis. Furthermore, a growing body of research has shown the importance of considering small units of analysis when studying crime (see Section 7.1).

#### 8.5 MEASURING THE INVOLVEMENT OF SMDs IN HANDLING STOLEN METAL

Many jurisdictions have recently increased the regulation of SMDs in an attempt to reduce metal theft. These measures are commonly based on the central assumption of the MRA that by increasing the effort and/or risk involved in selling stolen metal, thieves will be dissuaded from stealing metal in the first place (see, for example, the comments of law-makers reported by Amirfazli and Hyndman, 2012, p 251).

Direct measurement of the flow of stolen metal through the scrap-recycling process is not presently feasible. It is usually impossible to identify the origin of any particular piece of metal once it has begun to be processed by an SMD, because the first stages of processing involve stripping any non-metal sheathing and compressing metal into bales for transport (Sijstermans, 1997). For these same reasons, inspection of SMDs to identify stolen metal is unlikely to help in quantifying SMD involvement in metal theft<sup>2</sup>. Although research is currently being undertaken to improve the traceability of scrap metal (e.g. by Dettman et al., 2014), the long metal life-cycle (Spatari et al., 2002, p 37) means that almost all metal being recycled today is not traceable.

Handling stolen goods is an “intangible crime” (Chappell and Walsh, 1974b, p 494), i.e. one that is known about by people other than the perpetrators only when detected by the police. Given that prosecuting handlers

<sup>2</sup> That is not to say that such inspections may not be a useful policing tactic to gather intelligence, increase the perception of apprehension-risk among offenders or identify regulatory offences, simply that inspections are unlikely to be useful for quantitative data analysis.

of stolen goods has often proved more difficult than prosecuting thieves (Chappell and Walsh, 1974b, p 488), it is unlikely that those offences that are detected by the police are a substantial or representative sample of all offences, rendering them less useful for criminological analysis.

## 8.6 DATA AND HYPOTHESES

Given that direct measures of the extent to which SMDs are involved in metal theft appear not to be feasible, the the research presented in this chapter adopted a different approach. The MRA is based upon the assumption that the frequency of theft depends partly upon the availability of outlets for thieves to sell their stolen goods. If this assumption is true in the case of the theft of metal, it may be possible to identify this by testing for a spatial relationship between the number of SMDs in an area and the number of metal thefts. The present study seeks to build upon the test of this hypothesis by Whiteacre and Howes (2009) by attempting to address the issues of data quality and spatial accuracy discussed above.

Given that the locations of metal thefts were only known at the resolution of the nearest station, it was necessary to translate any other variables into the same spatial resolution. Calculating the nearest station to a particular location is complicated because the nearest station (by Euclidean distance) to a particular line-side location may be on a different line. For this reason, the railway network was divided into polylines (one for each of the 1,974 stations in England) where every point on each polyline was closer to one station than to any other (Figure 5.2). Other points of interest (such as SMDs) could then be counted by determining which polyline the point was closest to. This allowed the study to programmatically replicate the procedure that BTP officers use to determine which is the nearest station to the location of a particular crime. The distance from a feature to the nearest line was considered to be more important than the distance to the nearest station, since it is from the line-side that most metal is stolen.

The Environment Agency (EA) provided data on the locations of 2,020 SMDs in England. These data represent all registered SMDs as of December 2013, except those that only handle metal from agricultural sources or dismantle used motor vehicles<sup>3</sup>. The list was derived from the licences that

<sup>3</sup> These premises were excluded because checks on a sample of them suggested that they accept metal only for specific purposes: on satellite images, many of the agricultural processors appeared to be farms.

SMDs are required to have as dealers in waste. There are two main limitations of this dataset. Firstly, some SMDs will be operating illegally without the appropriate permit and so will not be present in the data. Secondly, the EA data do not include the dates on which each SMD began and finished operating, because there is no requirement to notify such information to the authorities. As such, it is possible that some of the SMDs in the data had ceased trading.

To estimate the quality of the data in this regard, two checks were carried out. Firstly, the date on which each SMD had last updated their registration (for example to change the name of the registered dealer or notify a change of location) was ascertained. The median date on which SMDs had updated their EA record was March 2012, twenty-two months before the data were extracted. However, 555 SMDs had last updated their records before January 2009, five years before the data extraction. To ascertain what proportion of those dealers were still trading at the same location, a random sample of 200 addresses were checked using the satellite imagery on Google Maps (Google, 2015)<sup>4</sup>. In 92% of cases, various types of scrap metal were visible at the stated location, while in 2% the premises appeared to be used for industrial purposes. In the remaining 6% of cases the location appeared to be a residential address, suggesting either that the land had been re-used or that a SMD had registered their business at their home address. The apparent longevity of SMDs at one location was also evident in statistics produced by the Office for National Statistics (2013b, table B3.3), which showed that 64% of UK companies classified as engaged in “wholesale of waste and scrap” had been in business for ten years or more, compared to 44% of all UK businesses. Only 14% of scrap companies had been trading for less than two years, compared to 17% of all businesses. This longevity may be due to many SMDs being family businesses, as well as the noise and dust generated by scrap recycling making it difficult to establish new sites without local opposition.

#### 8.6.1 *Hypotheses*

The main hypothesis explored with these data was that thefts of metal from the railway network will occur more frequently in areas where there are

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<sup>4</sup> The imagery available on Google Maps is believed to be no older than three years (Vandeviver, 2014, p 2).

more SMDs to which thieves can attempt to sell the metal. This hypothesis tests both the basis of most recently introduced regulations of SMDs, and the central underlying assumption of the MRA that the frequency of theft depends in part upon the availability of potential fences for stolen goods.

To ensure the validity of this test, several alternative explanations for a potential link between the locations of metal thefts and of SMDs had to be accounted for. One potential explanation for a link is that both SMDs and railway lines might be more common in areas with many industrial and other premises that use high volumes of metal, increasing both the availability of metal to steal and the number of SMDs. To control for this, data were obtained from Ordnance Survey (the national mapping agency for Great Britain) on the locations of manufacturing, energy-production, waste-disposal and mining premises. To make these data comparable to the metal-theft data, a count was taken of the number of such premises within a buffer surrounding each network polyline (see Figure 5.2), and then converted into a rate of such premises per square kilometre of land within the buffer. The choice of buffer distance was inherently arbitrary, since it was not possible to know how far the awareness space of offenders would extend from the location of a theft. To investigate the sensitivity of the results to the choice of buffer radius, the analysis was repeated for buffer radii from 1 to 20 km in 1 km increments.

In order to control for the density of residential and ambient population in each area, counts of residential, industrial and other buildings were obtained. However, these could not be used in the regression model because the densities of dwellings and industrial premises were highly correlated (Spearman's  $\rho = 0.97$ ). This correlation may seem very high, but this is likely to be a reflection of the organic way in which the English built environment has developed over centuries, with land use often determined before the concept of town planning had developed. As a result, industrial, residential and other premises are often adjacent to one another on the same street. In order to include the residential character of each area in the model, buffer areas were categorised as being either urban, suburban or rural. Urban areas were defined as those with more than 500 residents per square kilometre, derived from the density of dwellings based on the national mean household size of 2.3 people (Office for National Statistics, 2013a, p 7), while suburban areas were defined as those non-urban areas with more than 150 residents per square kilometre.

A second potential explanation for a link between the locations of scrap yards and those of metal thefts is that metal thefts might be more common in areas that frequently suffer other types of crime. This may be particularly relevant since SMDs are often sited in poor inner-city areas (Ackerman and Mirza, 2001) that tend to experience higher volumes of theft. To control for this variable, the rate of police-recorded burglaries (both residential and non-residential) per 1,000 buildings was calculated for each buffer area, derived from Home Office (2015).

The final alternative explanation considered was that both metal thefts and scrap yards may be more common in areas that have particularly good links to the road-transport network. More-accessible locations are known to experience higher levels of property crime (Beavon et al., 1994; Johnson and Bowers, 2010), and they are presumably also beneficial for SMDs that need to be accessible to customers. To control for this possibility, the density of major roads (expressed in kilometres of such road per square kilometre of land) was calculated for each buffer area. Main-road density was used because main roads are likely to contribute more towards overall accessibility.

Two further variables were required to account for the nature of the data. The first was the natural log of the length of railway line in each buffer area, to act as an exposure variable to account for the greater availability of metal in longer polylines. The second was a spatial lag variable designed to account for the inherent autocorrelation present in spatial data (for a comparison of similar methods, see Anselin et al., 2000, pp 238–241). For each polyline, this variable was calculated as the mean number of metal thefts in directly adjacent polylines, using ‘queen’ contiguity. For example in Figure 5.2, the spatial lag variable for the polyline  $x$  would be the mean of the number of thefts recorded in polylines  $m$ ,  $n$ ,  $p$  and  $q$ , but not polyline  $r$  because it is not directly adjacent to  $x$ .

## 8.7 METHODS

Several regression models are available for analysing count variables such as the dependent variable in the present study (for a review of regression methods for crime-count data, see Osgood, 2000). In common with many crime variables, the number of metal thefts at each station was found to be over-dispersed: the mean number of thefts (5.8 per station) was less than the variance (201.5). The standard Poisson model for count data is



known to perform poorly when used on over-dispersed data, but several alternatives are available (for a recent review, see Lord et al., 2013). This research used a negative binomial (NB) model because, unlike alternatives such as hurdle or zero-inflated Poisson models, it does not require the assumption of the over-dispersion being caused by an underlying two-stage process. Analysis was conducted in R (R Core Team, 2013) using the 'CAR' and 'MASS' packages (Fox and Weisberg, 2011; Venables and Ripley, 2002), while spatial calculations were completed in ArcGIS 10.1 (ESRI, 2012).

All of the variables were positively skewed, as expected with counts. Log transformations were considered for all predictors, but the presence of zero values made this undesirable in several cases. The length of railway line in each buffer was logged, because it was strictly positive and extremely skewed.

## 8.8 RESULTS

Regression models were run for buffer radii from 1 to 20 km in 1 km increments. In choosing an appropriate radius, it was necessary to balance two conflicting concerns. If the chosen radius were too small, many cases would have zero counts for variables, for example if there were no SMDs within the buffer. Conversely, if the chosen radius were too large, a substantial proportion of places would be within the buffer of more than one station and so the predictor values would tend to be very similar between cases<sup>5</sup>. In order to balance these two issues, it was decided to use results from the model with the smallest buffer radius that produced stable co-efficients compared to the other models.

Below 5 km, there were large variations in co-efficients with each 1 km change in buffer radius, while from 5 km upwards the co-efficients were broadly similar across models. Table 8.1 shows co-efficients ( $\beta$ ) for the model produced with a 5 km (3 mile) buffer, along with standard errors, rate ratios (exponentiated coefficients,  $e^\beta$ ) and expected percentage changes ( $e^\beta - 1$ ). This final value is the percentage change in the dependent variable for every one-unit change in the value of the relevant predictor. Generalised

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<sup>5</sup> It was necessary to allow buffers to overlap in order to plausibly model the factors influencing offender decision making. For example, there was no reason to think that offenders would not choose to sell metal to an SMD within the buffer of one polyline simply because that scrap yard happened to be marginally closer to a different railway line. Although spatial dependence was accounted for by including a lag term in the model, it nevertheless appeared prudent to minimise its extent.

Table 8.1: *Regression model for metal thefts and SMDs.*

	$\beta$	SE	$e^\beta$	expected change	$\sqrt{\text{VIF}}$
constant	-0.62***	0.122	0.54	—	—
SMDs per 10 km <sup>2</sup>	0.11**	0.035	1.12	12%	1.3
industrial premises per 1 km <sup>2</sup>	-0.03*	0.011	0.97	-3%	2.8
burglaries per 1,000 buildings	0.02***	0.002	1.02	2%	1.2
km major roads per 1 km <sup>2</sup>	0.12	0.015	1.13	13%	2.5
urban area <sup>†</sup>	1.23***	0.133	3.43	243%	1.0
suburban area <sup>†</sup>	0.59***	0.141	1.81	81%	1.2
km of railway line	0.09***	0.005	1.10	10%	1.1
mean thefts at adjacent stations	0.05***	0.003	1.05	5%	1.1

\*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$  <sup>†</sup> compared to rural area

variance inflation factors (Fox and Monette, 1992) were calculated to take into account the population-density variable being categorical: all the factors were less than four. Figure 8.1 shows confidence intervals around the parameter estimates.

One disadvantage of NB models is that there is no single co-efficient of determination equivalent to the  $R^2$  value in ordinary least-squares regression. Various pseudo- $R^2$  statistics are available, of which the present study used that suggested by Cragg and Uhler (1970, p 400). This compares the model under study with a null model containing no predictors. The model reported here produced a pseudo- $R^2$  of 0.41, suggesting that there is unmodelled variation in the data. This is not surprising, since the model was not able to take account of, for example, the fencing preferences of individual metal thieves or the willingness of individual SMDs to buy stolen metal.

The variable producing the greatest expected change in the number of metal thefts was the density of dwellings in the local area: a polyline in an urban area would be expected to have 3.7 times more thefts than a rural one, while a suburban polyline would be expected to have 1.9 times more thefts than a rural one.

The number of SMDs per 10 square kilometres (sq km) of buffer was found to be positively associated with the number of metal thefts: each additional SMD per 10 sq km was associated with a 28% rise in metal theft. Each additional burglary per 1,000 buildings per year was associated with a 2% increase in metal thefts in the model constructed using a 5 km buffer, while each additional industrial premises per 1 sq km was associated with a

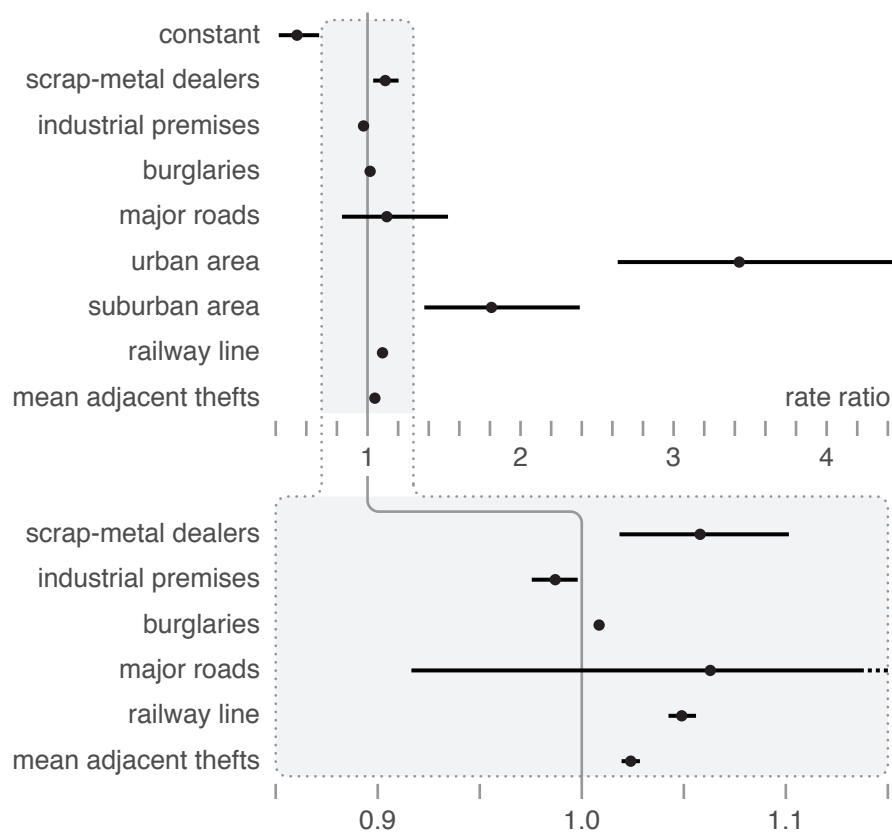
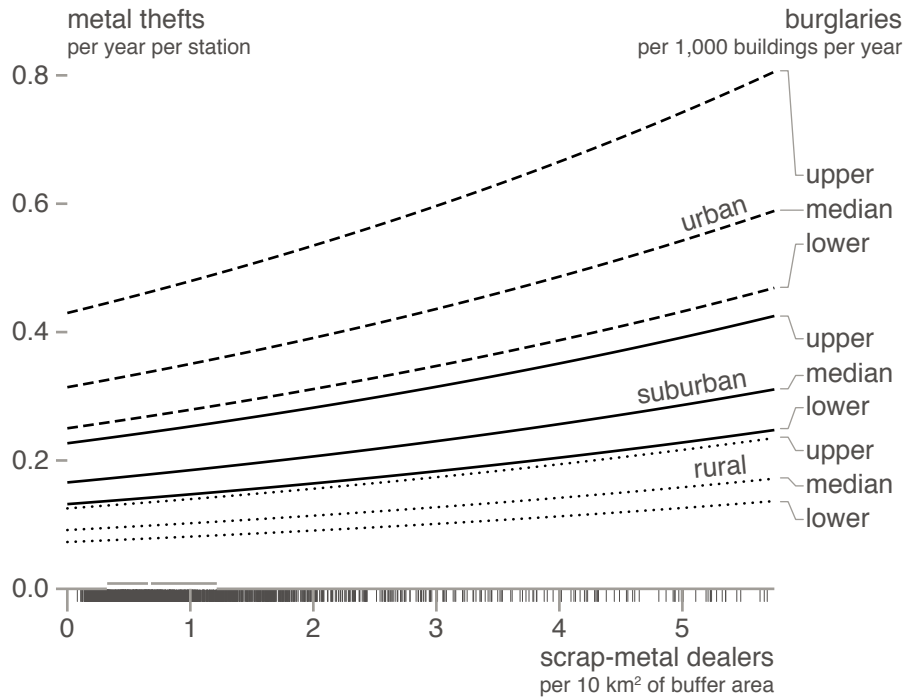
Figure 8.1: *Confidence intervals (95%) for SMDs regression model.*

Figure 8.2: *Variations in predicted number of metal thefts.*

The predicted number of thefts is shown with variations in the density of SMDs for urban, suburban and rural areas with burglary rates equal to the lower quartile, median and upper quartile rates. All other variables were held at their median values.

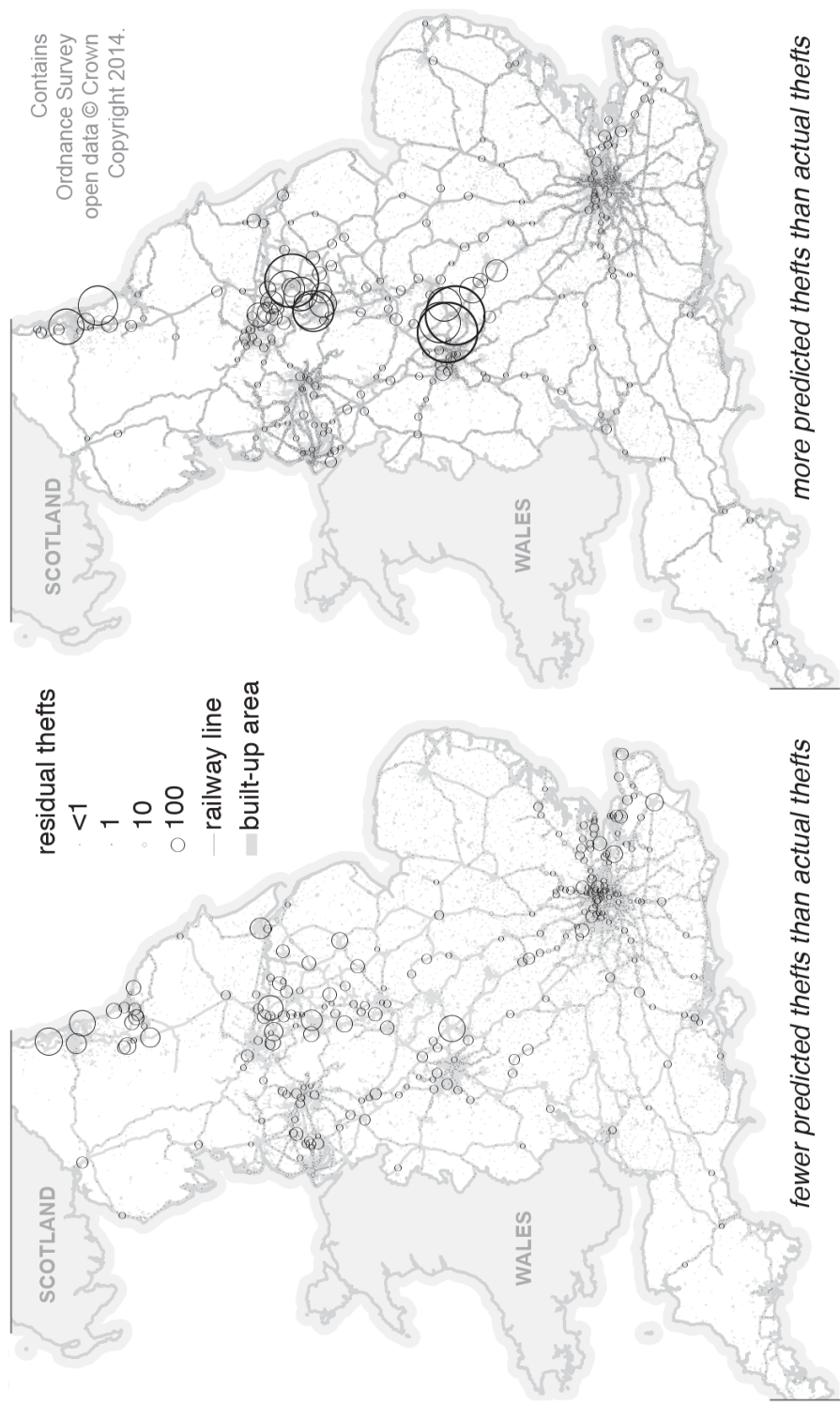


5% decrease. However, the significance of these predictors appeared to be sensitive to buffer radius, with the co-efficients not reaching significance in models with different radii. As such, these results should be treated with caution.

Figure 8.2 shows how the expected number of thefts predicted by the model increases with the number of SMDs, in urban, suburban and rural areas. The expected increase in the number of metal thefts with a one-unit increase in the number of SMDs (equivalent to the slope of the curve) is considerably larger in urban areas than in rural or suburban areas.

Figure 8.3 shows the difference between the actual number of thefts in each station polyline and the number predicted by the model. Since the predicted number must be non-negative, these residuals will be positively skewed. Large residual values appear to cluster spatially, with at least three clusters of over-prediction apparent. This suggests that the frequency of theft depends partly on variables not included in the present model and that at least some of those unmodelled variables exhibit spatial clustering.

Figure 8.3: Map of regression residuals.



## 8.9 DISCUSSION

The analysis presented in this chapter found a significant positive association between the locations of SMDs and the locations of metal thefts from railways in England. This was the case even after population density, accessibility, industrialisation and the local burglary rate had been taken into account. Although only an indirect test, and subject to the limitations discussed below, this finding is relevant to both the MRA and current efforts to reduce metal theft through a focus on SMDs. Empirical support for the assumptions underlying the MRA is particularly valuable because although those assumptions may appear intuitive, existing evidence supporting the MRA is surprisingly limited.

The main results presented above are for a 5 km buffer around each railway line. As explained in Section 8.8, this was the smallest radius that balanced the potential problems of loss of power due to zero counts and loss of validity due to overlapping buffers. Five kilometres may appear to be a small distance for offenders to travel after stealing metal. Existing evidence on the journey after crime is very limited, but suggests that offenders travel only short distance to dispose of stolen property (Lu, 2003). Short journeys would be expected from a rational-choice perspective because the longer thieves are in possession of stolen goods, the greater the risk of them being apprehended. It is for this reason that thieves generally try to sell-on goods very quickly (see Section 3.3), during which time they will only be able to travel a short distance. Rapid sale is likely to be particularly important for metal thieves, who may well know that police frequently stop and inspect vehicles carrying scrap metal.

The present results support the finding of Whiteacre and Howes (2009) that metal thefts were more common in areas with more SMDs, but also extend them in several ways. The present work was able to control for the amount of metal available for theft by including the length of railway line in each station polyline as a predictor in the model, as well as including urbanisation and main-road accessibility as additional variables. The results presented here also benefited from the availability of more comprehensive data on both the locations of metal thefts and of SMDs. This work was able to study much smaller and much more varied geographical areas, including rural and suburban areas as well as cities. Finally, this research used a regression model

suited to a dependant variable in the form of incident counts, rather than using an ordinary least-squares (OLS) model that was potentially unsuitable.

Four other independent variables were found to be significant predictors of metal thefts. Both stations with longer polylines and those surrounded by areas of high metal-theft were found to themselves suffer from more metal thefts. Metal thefts were also much more common in urban areas.

That a greater density of industrial premises was found to be associated with fewer metal thefts contradicts the results of Whiteacre and Howes (2009) that such premises were associated with more metal theft. There are at least two potential explanations for this. Firstly, in the specific context of railway-metal theft industrial premises may be associated with greater guardianship (e.g. where factory staff load freight onto trains) and therefore experience fewer thefts. Secondly, since population and industry are highly positively correlated, it may be that the positive association between industry and metal theft found by Whiteacre and Howes (2009) was an artefact produced by not including a population-density variable in their analysis. However, since the significance of the industry-density variable appeared to be sensitive to buffer radius, it is also possible that the present result is erroneous.

The present findings may be relevant to a common criticism of studies of what Brion (1988) referred to as “locally undesirable land use” (LULU). Eck et al. (2007) observed that many types of non-residential land use (indeed, almost all types that have been studied) have been found to be associated with higher crime rates. Commenting on the generality of these findings, Wilcox and Eck (2011, pp 474–5) argued that it was likely to be the additional traffic that such facilities generated that was criminogenic, rather than any features of a particular type of land use. Land-use studies typically concentrate on a single type of facility, and so cannot distinguish between the influence of the specific facility-type and of the surrounding increase in ambient population (Wilcox and Eck, 2011, p 474). By controlling for both non-residential land use (through the industrial-density variable) and for the level of traffic in an area (through the main-roads variable) the research presented here was able to distinguish the association between SMDs and metal thefts from any association due to those factors.

The finding that metal thefts are more common near to scrap yards, even when the alternative explanations suggested by Wilcox and Eck (2011) are taken into account, suggests that clusters of crime around certain types of land use may not be solely due to additional local traffic. A recent similar

finding by Boggess et al. (2014) that the density of medical marijuana dispensaries (another potential LULU) were a significant predictor of the local crime rate – even when the density of main roads was taken into account – also suggested that clusters of crime around particular facilities may not be solely due to variations in ambient population. More research into the interaction between land use, accessibility and the incidence of different crimes is certainly required.

There are several potential critiques of the present work. The first (found in any non-experimental study) is the issue of identifying causality. There are at least three potential explanations for the observed relationship between the locations of SMDs and of metal thefts: the presence of more SMDs in an area may attract metal thieves, the presence of more stolen metal in an area may attract SMDs, or a third factor may attract both SMDs and metal thieves. Of these options, the second is perhaps the least plausible: most SMDs are long-established businesses (see Section 8.6), so few are likely to have gone into business in order to capitalise on the recent increase in the availability of stolen metal<sup>6</sup>. The possibility of a third factor causing the observed relationship cannot be discounted without experimental research, which would be impractical in the present case. However, the authors attempted to identify and control for potential confounding variables and held discussions with practitioners from both the police and the recycling industry for this purpose. All of the potential factors mentioned during these discussions were incorporated into the model reported here, but it is not possible to definitively exclude the possibility of an unidentified confounding variable. Nevertheless, the presence of more SMDs in an area providing an incentive for metal theft (by making it easier to fence stolen metal) appears to be the most plausible of the three potential explanations.

The second limitation of this work is that it does not distinguish an SMD that is actively involved in metal theft from one that takes equally active steps to avoid buying stolen metal. Eck et al. (2007) argued that in any group of places with a similar function, a small number of locations (which they dubbed “risky facilities”) will experience most crime, while most places in the group will experience no crime at all: Wilcox and Eck (2011, pp 476–7) dubbed this the “iron law of troublesome places”. Although there was no way to identify which SMDs were actively involved in handling stolen metal,

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<sup>6</sup> This is not to deny that the financial benefit from handling stolen metal (or refusing to do so) may influence the profitability of an SMD, or even make the difference between a profitable business and a loss-making one.



there is no reason to believe that this law does not apply in the present case. Indeed it is supported by the literature reviewed above: some SMDs are known to be heavily involved in handling stolen metal, some to be involved to a lesser extent and many (perhaps most) to be not involved at all. How to identify those 'risky' SMDs is one of the unanswered questions in tackling metal theft.

The final limitation of the work presented here is that it provides evidence only in relation to metal theft from railways. At the present time, this is largely unavoidable because it is only very recently that the police – and institutional victims of metal theft outside the rail industry – have begun to think of metal theft as a problem important enough to justify specific recording. Although this work used data on railway thefts, there are reasons to think that the results will apply at least to metal thefts from other infrastructure networks. Most metal thefts from railways involve theft of cable from railway telecommunications or power networks (Robb et al., 2014), which mirror the public networks operated by telecommunications and power distribution companies.

It might be thought that the scheduled nature of train services would mean that guardianship on railway lines would be different to that of other infrastructure networks. This would likely be true in some countries, but the UK rail network is very heavily used and the same tracks carry both passenger and freight services: over 1.3 billion mainline journeys are made each year (Office of Rail Regulation, 2012), with a mean of 34,307 trains passing any given point on the network each year (Eurostat, 2011). The complex nature of the timetable means that the distribution of guardianship at a given point on the network is unpredictable, except at night when far fewer services run (for further discussion of guardianship on the railway network, see Chapter 7).

The present results appear to provide support for the central assumption of the MRA that the availability of outlets for the disposal of stolen goods will be associated with the incidence of theft. In the present case, the more SMDs that are available to purchase stolen metal (wittingly or unwittingly) the more thefts there are in the local area. In turn, this finding suggests that there may be merit in the current attempts to reduce metal theft through a focus on SMDs. Given the existing literature on risky facilities, and the importance placed on specificity within the MRA, it remains an open question as to whether a focus on SMDs should take the form of regulatory action against

them as a class of business, or targeted action against those individual sites known to be involved in or facilitating crime. The former course of action, increasingly adopted by governments in the US and EU, inevitably involves interfering with legitimate businesses and is therefore *prima facie* undesirable unless it can be justified in crime-prevention terms. Such a justification might be found if it is not possible to reliably identify criminogenic SMDs, for example due to lack of reliable intelligence or sufficient resources for monitoring scrap yards. Alternatively, if evaluation research was to establish an overwhelming benefit from regulatory action, those benefits may outweigh the costs to the scrap-metal industry. In such circumstances, it may be justifiable to target criminogenic SMDs through regulatory action covering the entire industry. In any case, crime-prevention activity must be done ethically, as discussed in Section 2.2.4.

The research presented in this chapter adds to the literature on the market-reduction approach, on the regulation of scrap-metal dealers and on risky facilities. Further research will be required to ascertain the impact of the various laws being introduced to combat metal theft through the regulation of SMDs, particularly since different jurisdictions are introducing different combinations of measures. Paradoxically, while such research will become easier in future (as more data become available on how such laws are operating) it may also become less valuable since many governments will have already implemented such laws without the benefit of supporting research. It is this paradox that makes the current study valuable, by providing indirect evidence during the present period when direct tests are not possible except in those few jurisdictions that implemented SMD laws relatively early. The evidence presented here is certainly imperfect, but it is better to offer imperfect evidence (with its imperfections clearly stated) than to allow policy makers and practitioners to work in an environment devoid of any evidence at all.









## METAL THEFT AND ORGANISED-CRIME GROUPS

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### SUMMARY

- The police and others have argued that a substantial minority (20–30%) of metal thefts are linked to organised crime groups (OCGs), but this has not been tested empirically.
- Less than 1% of people charged with metal theft have previous convictions for offences linked to OCGs.
- Police intelligence information linked 1.3% of metal thieves to OCGs of any type.
- Metal thieves typically travel very short distances to offend, consistent with previous studies of volume-crime offenders but not with studies of OCG members.
- Sophisticated offending of the type that may require the involvement of an OCG was found in only 2% of metal thefts.
- Overall it appears that OCGs are involved in metal theft far less often than previously supposed, which has implications for how metal theft is tackled.

### 9.1 INTRODUCTION

As described in Chapter 1, the emergence of metal theft as a crime problem has led to significant interest among policy makers. One centre of this interest has been the presumed involvement of OCGs in metal theft. Both the UK and EU organised-crime threat assessments identify OCGs as being involved in metal theft (HM Government, 2013, p 21; Europol, 2013, p 25), a link also discussed in the media (e.g. Buckley, 2007; Carter, 2013). BTP estimates that up to 30% of metal theft is committed by OCGs, while the Association of Chief Police Officers (ACPO) states that there are 205 OCGs involved in metal theft in Britain (House of Commons Transport Committee, 2012). In a report for the UK Home Office, Mills et al. (2013) estimated that 20% of metal theft related to organised crime.

These estimates have generally been accepted uncritically. However, there is reason to think that official sources may over-estimate the involvement of OCGs in crime problems. Mills et al. (2013) reported police estimates of OCGs involvement in various crimes, but these appear to differ substantially from what might be expected based on available evidence. For example, all cash-in-transit robberies were judged to be committed by OCGs, even though several previous studies have found some to be committed by amateur, opportunistic offenders (Willis, 2006; Hepenstal and Johnson, 2010). Similarly, all distraction burglaries were claimed to be committed by OCGs, despite a recent review by Gorden and Buchanan (2013, p 502) noting most offenders were dependent on drugs or alcohol.

Felson and Boba (2010, p 11) argued that the public often overestimate the degree to which offending is organised, that advanced levels of organisation are unnecessary for most types of crime, and that such organisation makes

some crimes more difficult by introducing needless complexity. Although police officers can be expected to know more about crime than members of the public would, previous research suggests that officers' perceptions are sometimes inaccurate. Ratcliffe and McCullagh (2001) found that officers could not pinpoint the locations of vehicle-crime hotspots, while Roach and Pease (2014) found that officers substantially overestimated the homogeneity of offending careers. Gregory (2003) found that police descriptions of the geographic reach of OCGs and the ethnic make-up of their members were not supported by analysis of police intelligence information. These examples illustrate the importance of empirically validating police perceptions of a crime problem.

The purpose of the analysis reported in this chapter was to seek evidence to test police estimates of the involvement of OCGs in metal theft. This is important for several reasons. Firstly, in many countries OCG involvement in a crime attracts additional funding or involvement of specialist units; unnecessary allocation of such resources may cause needless expense or shortages elsewhere. Secondly, police often have additional legal powers to combat OCGs – for example freezing and subsequent forfeiture of financial assets – that are unavailable otherwise (Finckenauer, 2005, p 70). Use of these powers when there is no actual involvement of OCGs may lead to disproportionate interference with suspects' rights. Thirdly, OCG involvement may make it easier to attract support for police action from politicians, the media and the public, but perceptions of police legitimacy may be damaged if such support subsequently appears to have been based on a false premise.

At the tactical level, what works to prevent organised crime may not work if the crime is largely committed by criminals not linked to OCGs. Attempts to tackle OCGs typically focus on long, expensive and complicated criminal investigations that aim to incapacitate offenders through imprisonment. This may be an effective method of crime prevention if offences are being committed by a small number of offenders or offender groups. However, there is substantial evidence that for many crime problems, prevention activity is most effective when it is focused on protecting potential targets and securing places, rather than focusing on offenders (Clarke, 1997). Thus an erroneous (but well intentioned) focus on investigating OCGs may deflect police resources from activities that could have a much larger impact on crime.

## 9.2 DEFINING AND MEASURING ORGANISED CRIME

In order to identify the degree to which OCGs are involved in metal theft, it is necessary to consider what an OCG is, a question that has received sustained academic attention but to which as yet there appears to be no accepted answer (Albanese, 2000; Finckenauer, 2005), partly because public and professional definitions are so different from one another (Hagan, 1983, p 52).

Early definitions of OCGs tended to focus on mafia-type organisations in the US, particularly those of Italian descent (Smith, 1971, p 1). Since these groups were believed to be hierarchical and monopolistic, to corrupt public officials and to use violence for internal control (Hagan, 1983, p 53), that is how organised crime as a whole was characterised. Subsequent scholars suggested broader definitions to incorporate activities they considered as being organised crime that did not fit within the common mafia-type model. At the extreme, Cohen (1977, p 100) argued that all crime (and, indeed, all behaviour in society) was inherently organised, and so any distinction between organised and non-organised crime was arbitrary. Others attempted to define organised crime by listing activities in which OCGs were often involved: typically drug trafficking, illegal gambling, prostitution and extortion (Malone, 1972, p 331). Such lists are ultimately unsatisfactory, because almost any sort of crime can be committed by individuals acting alone (Finckenauer, 2005, p 64). Although some crimes seem to require organisation (for example in transporting drugs from producing to consuming countries), even apparently clear-cut examples do not universally involve an OCG: “anyone can have a whip-round, take a cheap flight to Amsterdam and become an international drugs smuggler” (Swain, 2008, p 5). Definitions based on list of offences are particularly inappropriate for identifying the involvement of OCGs in crime types (such as cyber crime) that emerge only after the list is drawn up.

These difficulties and others have led to increasingly broad definitions being adopted over time, partly out of a concern not to restrict practitioners’ ability to tackle organised crime (Finckenauer, 2005, p 68). The UK government currently uses the definition set out in the United Nations Convention against Transnational Organized Crime (UNTOC):

“a structured group of three or more persons, existing for a period of time and acting in concert with the aim of committing one or more serious crimes . . . in order to obtain, directly or indirectly,



a financial or other material benefit” (United Nations Office on Drugs and Crime, 2004, p 5).

The UK government has defined “serious crime” for this purpose as being any offence carrying a *maximum* penalty of seven or more years in prison, regardless of the actual sentence imposed (Serious Crime Act 2015, section 45).

The potential over-inclusiveness of this definition can be seen by considering a group of teenagers (one of them acknowledged as the group ‘leader’) who periodically break into local cricket pavilions to steal a bottle of vodka because they are too young to obtain it legally. Such a group would appear to fit all the requirements of the UK definition<sup>1</sup> but it would be difficult to convince a person on the street that it was a “serious crime” being committed by an OCG. This highlights another issue: the need for legal definitions to bear some resemblance to what a reasonable person would consider to be organised crime.

One potential solution to the problem of defining the term OCG is to consider it as a problem of degree, not of category. Hagan (1983, 2006) argued that categorical definitions are only ever likely to be tenable in extreme cases, where something is obviously organised or obviously not. Instead, he suggested that the organisation of a crime group be seen as a continuum: it may be slightly organised, mostly organised or highly organised. This conception also allows consideration of the distinction made by Schelling (1984, p 180) between organised crime (committed by OCGs) and “crime that is organized”. For example, it may be that a house burglar plans his offending in advance – for example by borrowing a van from a friend or watching a street to see when a resident goes on holiday – but it would be difficult to call the burglar and his friend an OCG. The lack of a clear and widely accepted definition of an OCG makes it difficult to measure the involvement of OCGs in any particular crime type. The notion of crime organisation as a continuum makes it clear that the relevant question is not ‘are OCGs involved in this type of crime’ but instead ‘to what extent are OCGs involved’.

A final definitional issue relates to the relationship between the organisation of a crime and its seriousness. While it might be thought that the more serious a crime is, the more likely it would be the product of an OCG, this is not necessarily the case. Firstly, members of OCGs commit

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<sup>1</sup> Section 9 of the Theft Act 1968 sets the maximum penalty for a non-residential burglary as ten years imprisonment, while section 7 sets the maximum penalty for theft as seven years.

not only serious but also minor offences. Roach (2007) found that people stopped for traffic violations during an operation targeting visitors to a prison were disproportionately likely to have previous convictions for a range of serious offences including drugs supply, while Aronowitz (2001) reported on the involvement of OCGs in begging. Conversely, a great deal of serious offending takes place without the involvement of OCGs. Bullock and Tilley (2002, p 33) found that 40% of shootings in a large English city were not believed to be gang related, while Hopkins et al. (2012, p 296) found that only 6% of non-terrorist homicides in England and Wales involved links to OCGs. Crime need not be organised to be serious, nor be serious to be organised.

### 9.3 FEATURES OF OCG INVOLVEMENT IN METAL THEFT

In the absence of an accepted definition of an OCG, the present research used an alternative method to establish the extent of OCG involvement in metal theft. Firstly, features of the metal-theft phenomenon were identified that practitioners have used to support their proposition that OCGs are involved. Once identified, empirical tests were conducted to determine whether the metal-theft problem does in fact have those features. The involvement of OCGs in metal theft is therefore not measured against a universal definition of an OCG (since none exists) but against the features described by practitioners. If evidence of those features is found, it can be said that metal theft involves OCGs in the manner described by practitioners. If no such evidence is found, this would suggest that metal theft does not have those features, i.e. either that OCGs are not involved in metal theft or are involved in some way not identified by practitioners.

In order to identify features of metal theft that could be tested, discussions were held with a variety of practitioners (including detectives, intelligence analysts and representatives of infrastructure companies) who were members of an EU project that aimed to increase and exchange knowledge of metal theft. Previous official reports and statements by practitioners were also analysed. From this process, four features of metal theft that practitioners claim suggests the involvement of OCGs were identified that could be tested with data that could be made available. To validate this process, the identified features were presented to and agreed by the members of the EU project. This approach is an implementation of the hypothesis-testing approach to

crime analysis (Chainey, 2012), in which plausible candidate explanations for crime patterns are drawn from practitioner expertise and then tested using empirical methods.

The first identified feature (F1) was that if OCGs are involved in metal theft, it is likely that metal thieves would have previously been involved in offences commonly associated with OCGs, such as drug trafficking or counterfeiting currency. This statement could be tested by analysing the criminal histories of known metal thieves.

Since the secretive nature of OCGs often makes prosecutions difficult, it is possible that such groups might be involved in metal theft without that being evident from criminal records. To account for this possibility, the second feature (F2) was that if OCGs are involved in metal theft then police would be likely to hold intelligence information suggesting that individual metal thieves are involved in OCGs, even if that involvement could not be proven in court. This statement could be tested by analysing information held by the NCA about the involvement of metal thieves in other offending.

One feature of metal theft cited by police, government and infrastructure companies as evidence of the involvement of OCGs is the willingness of offenders to travel “hundreds of miles” to steal metal (see, for example, House of Commons Transport Committee, 2012). More generally, if OCGs were commonly involved in metal theft, it might be expected that OCG members who steal metal would make use of the capabilities of such groups to travel further than other offenders are able to do in order to find the most suitable targets for offending, both while stealing metal and in their other offending (F3). Evidence on the distance to crime for OCG offenders is limited, but van Daele and vander Beken (2009, p 5) found that OCG members in Belgium travelled a mean distance of 25 miles (40 km) in order to offend, compared to 11 miles (17 km) for other acquisitive-crime offenders.

The final feature (F4) was that if OCGs are involved in metal theft then it might be expected that some metal thieves would use sophisticated methods to steal metal, using the capabilities and resources of an OCG to maximise their profit from an offence. For example, a metal thief linked to an OCG might be able to obtain forged documents that would allow them to steal large amounts of railway cable from a storage depot, while an offender without such links could only obtain smaller amounts of metal left lying at the side of railway lines. This statement could be tested by analysing the methods used by offenders to steal metal.

The identified features are not suggested to be infallible indicators of the involvement of an OCG. Even the highest estimates of the involvement of OCGs in metal theft – for example those reported by House of Commons Transport Committee (2012) – suggest that many metal thefts are committed by offenders unassociated with OCGs. Conversely, it is known that people who commit very serious crimes also commit minor offences (Roach, 2007), so some OCG members would be likely to be found in a sample of offenders convicted of any crime, however minor. Assessing the validity of the statements is therefore one of degree: the operant question is ‘if OCGs were involved in metal theft to the extent claimed by the police, would we expect this feature to be present *to this extent?*’.

The mix-methods analytical approach adopted here accepts that each method will be potentially subject to criticism by those who consider that a particular feature is not relevant for measuring the involvement of OCGs in metal theft. As is common in social research, there are also data limitations that could affect the validity of the research findings. Two other approaches would have been possible. Firstly, a single method could have been chosen based on a single definition of organised crime: as discussed above, this would be unsatisfactory in an environment where no single definition is widely accepted. Secondly, the current research could have been delayed until an accepted definition of organised crime had been found. However, the question of definition shows little sign of being settled imminently, and meanwhile policy makers and practitioners must continue to make decisions about how to combat OCGs, regardless of whether the definition is settled.

As discussed in Section 2.3, social theory can be useful if it is ‘good enough’, i.e. if it has practical utility for explaining policy and that “can adapt to the changing needs of practice in relation to this policy” (Smith and Clarke, 2012a, p 292). Further research may show such a theory to be inadequate, but that does not mean that it cannot be useful in the interim – Smith and Clarke (2012a) argue that such a theory remains “good enough” as long as it meets the needs of practitioners. In this tradition of policy-oriented research, the present study sought to use “good enough” data and “good enough” methods to provide useful answers. Such research may be useful to practitioners and policy makers, even in the knowledge that better data and better methods may eventually render the present results obsolete.

## 9.4 CHARACTERISTICS OF METAL THIEVES

Of the 839 metal thieves in the sample, 97% were male and 94% were white. This compares to an overall picture of 78% of offenders on PNC who were male and 81% who were white (Francis et al., 2013, pp 21–23), and higher than the 70% of OCG members studied by Gregory (2003, p 88) who were white. Eighty-three percent of metal thieves were British nationals – broadly comparable to the 80% of UK nationals among offenders studied by Francis et al. (2013, p 21) – 12% were nationals of other EU member states and the remaining 5% were nationals of non-EU countries. The most common non-UK nationalities were Romanian (8%), Polish (1%) and Irish (1%).

The median age of offenders when they were first sanctioned for an offence was 16 years, with 61% of offenders first sanctioned while still a juvenile (i.e. aged under 18). This is a higher proportion than the 46% of offenders first sanctioned while under 18 reported by Francis et al. (2013, p 30). The median age of offenders when they were first sanctioned for metal theft was 27 years, with a median of 6.5 years elapsing between first sanction for any offence and first sanction for metal theft. These last two statistics should be treated with caution, however, since they are likely to be skewed by the frequency of metal thefts being much higher in recent years than it was previously.

The median length of a criminal career for offenders in the sample was 9.7 years<sup>2</sup>, during which offenders received a median of 1.9 sanctions per year, much higher than for most offenders on PNC (Francis et al., 2013, p 94). Half of metal thieves met the UK Ministry of Justice definition of chronic offending – having been sanctioned for 15 or more offences (Ministry of Justice, 2013, p 12) – compared to 5% of offenders in England and Wales (Owen and Cooper, 2013, p 11).

Half of metal thieves had been sanctioned for an offence related to metal theft only once, with 75% sanctioned for metal theft either once or twice. At the other extreme of the distribution, 10% of metal thieves ( $n = 84$ ) were responsible for 31% of metal-theft sanctions, and 5% of thieves ( $n = 42$ ) were responsible for 19% of sanctions. Nevertheless, for most offenders metal theft formed only a minority of their offending (15% of sanctions in the median case). This held largely true even for offenders ( $n = 31$ ) sanctioned for more

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<sup>2</sup> Criminal careers were calculated as the length of time between each offender's first and last sanction, as of the date on which data were extracted from PNC. It is likely that some offenders will go on to commit further offences in future, and so their careers will extend beyond that described here.

Table 9.1: *Offence categories for which metal thieves have been charged/cautioned.*

Offence type	Offenders	%
Theft	839	100
Criminal damage	494	59
Offences related to police/courts/prisons	467	56
Drugs possession, supply or manufacture	442	53
Violence (excluding sexual violence)	415	49
Public disorder	347	41
Weapons possession or supply	235	28
Fraud	176	21
Sexual offences	48	6
Other	460	55

than five metal thefts, for whom a median of 25% of all sanctions related to metal theft.

Table 9.1 shows the number of metal thieves sanctioned for offences in different categories. Unsurprisingly, theft was the type of offence most metal thieves had been involved in, followed by criminal damage and offences related to the criminal-justice system. This latter category includes offences such as failing to appear at court, breaches of police or court orders and so on.

Metal thieves had varied offending histories: 92% of offenders who had been sanctioned for more than one offence had been sanctioned for offences in more than one of the categories shown in Table 9.1. To quantify the variety of offending by metal thieves, a diversity index was calculated (Hirschfield and Bowers, 1997, p 1293) based on the categories shown in Table 9.1. This index could take any value between zero and 0.9 (Francis et al., 2013, p 109), where higher values indicate more-diverse offending. The median diversity index among metal thieves who had been sanctioned more than once was 0.65, indicating that metal thieves are typically not specialist offenders but commit a variety of different crimes.

Table 9.2 shows in more detail the types of other theft for which metal thieves were sanctioned. The most-common type was shoplifting, followed by non-dwelling burglaries and thefts of or from motor vehicles. The most-common non-theft offences for which metal thieves were sanctioned were driving a motor vehicle without insurance, possessing a controlled drug (most often cannabis, amphetamine or heroin), failing to surrender after being released on bail, driving while disqualified and criminal damage. More

Table 9.2: *Types of theft for which metal thieves have been charged/cautioned.*  
Excluding metal thefts.

Theft type	Offences	%
Shoplifting	2,033	20
Theft/taking of motor vehicle	1,484	15
Burglary (non-dwelling)	1,400	14
Burglary (dwelling)	1,112	11
Theft from motor vehicle	934	9
Handling stolen goods	744	7
Robbery/theft from a person	417	4
Possessing article for use in theft	323	3
Cycle theft	150	1
Other theft	310	3
Unknown type	1,316	13

than half of metal thieves (58%) had at least one sanction for an offence related to misuse of drugs or alcohol.

Overall, it appears that people who steal metal from the railway network in Great Britain are diverse, persistent, high-rate offenders who are likely to be male, white and slightly older than the typical offender.

## 9.5 PREVIOUS CONVICTIONS FOR ORGANISED CRIME

Evaluating F1 – that if OCGs are involved in metal theft then metal thieves will have previously been involved in other organised crimes – required use of an approach developed by Francis et al. (2013, p 12) for comparing OCG offenders with “general” offenders. PNC does not include a record of whether or not offences are related to organised crime, so Francis et al. (2013) deemed offences to be “indicative” of an offender’s involvement in an OCG if:

1. the offence was of a type believed to be associated with OCGs (see Francis et al., 2013, pp 83–89 for a list),
2. the offender was sentenced with at least one co-offender, and
3. the offender was sentenced to at least three years in prison.

The 185 offence types believed to be associated with OCGs were defined by a panel of researchers, policy makers and practitioners experienced in dealing with organised crime (for details, see Francis et al., 2013, p 14). The offences included illegally importing or supplying commodities such as

firearms, trademarked goods or controlled drugs; controlling prostitution or people trafficking; serious violence (particularly involving kidnapping or explosives) and money laundering or other serious fraud. This approach to defining organised-crime offences is not unproblematic: as discussed above, it is impossible to define a list of organised-crime offences with complete accuracy. However, the method was used here to allow comparison of the results with those reported by Francis et al. (2013) for both general and organised-crime offenders.

Of the 839 metal thieves in the final sample, four (0.5%) had a previous conviction that suggested their involvement in an OCG according to this definition. This compares to 0.2% of all offenders on PNC between 2007 and 2010 who had a relevant organised-crime conviction (Francis et al., 2013, p 14). All four convictions were for money laundering, and all related to laundering the proceeds of metal theft from railways – none of the offenders in the sample had a conviction for an organised-crime offence that was not linked to metal theft. The criminal records of these offenders showed that three had multiple convictions for acquisitive offences and possession of controlled drugs, suggesting that drug addiction may have driven their offending.

The objective of this classification was to identify offences that *may* be linked to organised crime, not to make a definitive identification. It is unlikely that all instances of any crime type would be linked to organised crime, and so it is possible that this procedure may have erroneously classified some offences as being related to OCGs that were not. Conversely, the requirement for a co-offender to also be not only identified but convicted, and for a particular minimum sentence to be imposed, might have resulted in some offences that were committed by OCGs not being identified. Although this method is imperfect, the very small number of metal thieves with previous convictions for offences believed to be related to organised crime suggests that the involvement of OCGs in metal theft may be less than previously believed, and that there is little evidence to support F1 except for a very small number of metal thieves.

## 9.6 INTELLIGENCE ON LINKS TO ORGANISED CRIME

PNC data are inevitably limited because they only include information on specific offences that the police can demonstrate the person committed. To



deal with this limitation, the personal details of each offender were checked against a variety of NCA organised-crime intelligence databases. These databases contain information about a range of criminality that the police suspect – but sometimes cannot prove – a person is involved in.

The sensitivity of the intelligence data mean that only limited information can be reported, even in aggregate form. Two categories of offenders were identified with potential links to OCGs, together comprising 11 known metal thieves (1.3% of the sample). This compares to an estimated 41,100 members of 9,200 OCGs that the police believe are involved in different types of organised crime across the UK (Association of Chief Police Officers, 2012, p 27).

The first category was of offenders suspected of being involved in the supply of controlled drugs. Mills et al. (2013, p 22) claimed that all drugs supply in the UK involves organised crime, but it does not follow that every person involved at any stage of the process is a member of an OCG. However, Williams (1998) argued that drug-trafficking groups often adopt a network structure that can be divided into two parts. Offenders in the core group tend to be closely linked, while those on the periphery may have contact with only one or two others: Natarajan (2006, p 179) found that 70% of people in a drug network were linked to only one other member. The available data did not allow identification of how central to a drug network the metal thieves were. However, all but one of the offenders in this category had multiple convictions for volume-crime offences such as shoplifting, failing to attend court and burglary, as well as at least one conviction related to alcohol or drug misuse. Two of the offenders had previous convictions for the supply of drugs, although in both cases this was a minority of their known offending. Although the available evidence is limited, on the balance of probabilities it appears that these offenders are more likely to be peripheral to any drugs-supply network than to be part of a core group, and appear to be more heavily involved in petty crimes than in those related to OCGs.

The second category of interest comprised offenders who were suspected of involvement in people trafficking. Like other types of criminal network, people-trafficking groups involve several different types of offender: those responsible for moving victims clandestinely into or within the UK, those who control victims and those who use the victims, for example for sexual or labour exploitation. Although it was not possible to identify the roles of metal thieves in any people-trafficking networks, one had a previous

conviction that indicated he had sexually abused a child as a 'customer' of a people-trafficking group. All the offenders in this group also had convictions for volume-crime offences, with offences related to alcohol-misuse (such as drink driving) being particularly prevalent.

Metal theft appeared to be peripheral to the offending careers of most offenders who were linked by intelligence to OCGs, with all but two such offenders being sanctioned for metal theft either once or twice. The narrative offence methods recorded on PNC for nine of the eleven offenders gave no indication that the metal thefts they were sanctioned for were any more sophisticated than for other offenders. The remaining two offenders appeared to be part of groups involved in stealing large volumes of metal in multiple parts of the country. As with F1, it appears that evidence to support F2 exists for only a very small minority of metal thieves, and that those offenders who are linked to an OCG are likely to be both on the periphery of that group and only incidentally involved in metal theft.

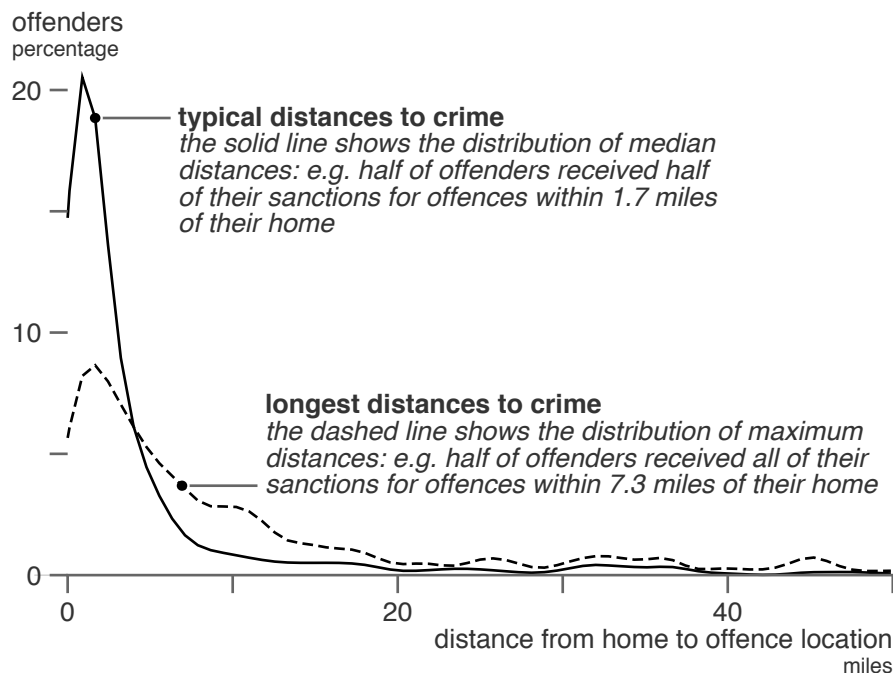
#### 9.7 DISTANCE TO CRIME

The third statement was examined by calculating the straight-line distance between each offence location and the offender's last known home address at the time of the offence. Previous journey-to-crime research has typically made such calculations based on the offender's home (see Townsley and Sidebottom, 2010, for a review), although offenders may travel to offences from an alternative base. When offender addresses had not been recorded at the time of arrest, the most-recent known address for that offender was used unless it was more than one year old (in which case the offence was excluded from the analysis). Distances to crime were calculated for 82% of all offences and 68% of metal thefts. When multiple offenders were identified for an offence, their journeys were treated separately.

The mean distance to crime for all offending (including metal theft) was 6.8 miles (11.0 km)<sup>3</sup>. This is slightly longer than mean distances found in studies of residential burglary reviewed by Townsley and Sidebottom (2010, p 900), which ranged from 0.4 to 2.5 miles (0.6–4.0 km). However, it is also much less than the mean distance of 25 miles (40 km) travelled by the acquisitive OCG offenders studied by van Daele and vander Beken (2009,

<sup>3</sup> Since most distance-to-crime research has been conducted in the US, those studies have typically quoted distances in miles. To aid comparison, the same convention has been used in reporting results here.

Figure 9.1: Median and maximum distances to crime for all offences committed by each offender.



p 5). However, the distribution of distances was heavily skewed and so the mean value (although commonly used in distance-to-crime research) is not representative: 40% of offences occurred within one mile of the offender's home and 58% within two miles; only 7% involved travelling more than 20 miles.

It might be expected that the distance travelled to commit a metal theft would be higher than that for offending generally, because the opportunity to steal metal exists only in certain locations. However, the increase in distance appeared to be small, with 31% of metal-theft sanctions being for offences within one mile of the offender's home address and 47% within two miles; only 10% involved travelling further than 20 miles.

Statistics based on aggregate distance-to-crime calculations might be misleading because they fail to account for potential variation between offenders and within the career of each offender Townsley and Sidebottom (2010). At the offender level, there are two potential measures of distance to crime: how far the offender typically travels, and the farthest they have ever been known to travel. Figure 9.1 shows these values as the distribution of median and maximum distances travelled by each offender. It can be seen that offenders typically travelled only a short distance, and that very few were ever sanctioned for offences further than 20 miles from their home.

Distances to metal thefts were broadly similar to those travelled for other offences: half of offenders committed half of their metal thefts within 2.3 miles (3.7 km) of home and all of their metal thefts within 3.0 miles (4.8 km). Only 17% of offenders had been sanctioned for a metal theft more than 10 miles from their home address, but a very small number of offenders were prepared to travel further: 1.4% of offenders had been sanctioned for a metal theft more than 100 miles from home.

Overall, it appears that a minority of metal thieves are prepared to travel moderate distances to steal metal and to offend in general, but – as has been found for other crime types – most metal thieves commit most of their offences very close to home. It is possible that this result is vulnerable to sampling bias, if offenders are more likely to be linked to offences committed closer to their homes. However, this potential source of error can be mitigated by comparing the present results to those of other distance-to-crime studies that used the same methods. Relatively, the distance traveled by metal thieves – both in general and specifically to steal metal – appeared to be much more similar to that found by previous studies of volume-crime offenders than those found by van Daele and vander Beken (2009) for members of OCGs. If willingness to travel long distances is a feature of an OCG, it appears to be a feature that is present for only a very small number of metal thieves.

#### 9.8 OFFENCE METHODS

The fourth statement was tested using the sample of 400 metal-theft offence methods described in Section 5.3.1. Grounded, descriptive codes were generated by the author to identify methods that were sophisticated or otherwise indicated the involvement of OCGs<sup>4</sup>.

Very few methods involved any degree of sophistication. Many appeared to be simple, for example:

“Report from security staff that they had spotted two youths pushing a trolley of [copper] cabling from the industrial area on [street name]. Tracks were followed and the stolen property

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<sup>4</sup> It was not possible for multiple researchers to independently code these values because access to the database required expensive and time-consuming security clearance that the agency providing the data were not able to provide for more than one researcher. It was not possible to use automatic data-mining tools to classify methods because of the wide range of codes, abbreviations and colloquial terms used in the offence descriptions, which would have made training such tools impractical.

was found at the rear of [suspect's address], suspect was arrested inside the property."

"Suspect drove [small motor vehicle] to trackside and cut [electrical cable] with a hacksaw. About 150 metres of copper cable was removed, coiled up and placed in his vehicle."

"Defendant entered fenced-off [railway] embankment [and] collected items of metal left there by [railway] staff. [Metal] passed through fence to co-defendant who prepared it for taking away ... by pedal cycle."

Offenders used simple equipment – hacksaws, screwdrivers and pliers – to cut-up metal (mentioned in 10% of cases) and wheeled rubbish bins or shopping trolleys to transport metal. Vehicles (mentioned in 22% of cases) were usually panel vans or ordinary cars, although there were also offenders on pedal cycles or on foot (mentioned in 8% of cases). Co-offenders were mentioned in 40% of cases, but often in conjunction with very simple methods, e.g.

"Male in company with two others used his girlfriend's car to drive to railway line ... jumped over fence and went onto tracks to collect any metal that was on the ground, passing it back over the fence to his two accomplices."

Nine offences (2% of the sample) involved an unusual degree of sophistication. Seven records described conspiracies between multiple offenders to steal large quantities of metal, while five involved the use of lorries equipped with cranes to remove large quantities of metal. In one case, the offenders had developed a technique to bypass systems designed to detect cable thefts, while one offence involved forged documentation used to convince security staff that the thieves had permission to remove scrap metal from a railway depot. It should be emphasised, however, that these offence methods stood out for how unusual they were: overall, there was little evidence to support F4.

## 9.9 DISCUSSION

The results presented here suggest that in almost all metal thefts there is no evidence of the involvement of an OCG. The 0.5% of metal thieves with

a previous conviction indicative of OCG membership (F1) was similar to the 0.2% of all UK offenders with such a conviction. Although 1.3% of known metal thieves were linked to an OCG by police intelligence (F2), this represents 0.02% of estimated UK OCGs members. Very few metal thieves appear to travel long distances to offend (F3), with almost all exhibiting travel patterns similar to those of 'normal' volume-crime offenders. Finally, only 2% of metal thefts were found to exhibit methodological sophistication that might be indicative of the involvement of OCGs (F4). Metal thieves are not typical offenders – they seem to be far more prolific than most – but there is little evidence of any but a few being involved in OCGs.

The limitations of each method are discussed in the relevant sections above. One general limitation of using PNC data is that some offenders may never be arrested, and that offences for which offenders are detained are not representative of their total offending. However, the 12% of metal thefts that lead to an offender being sanctioned (Robb et al., 2014) compares favourably to similar studies reviewed by Bowers and Johnson (2015, p 119). Furthermore, common alternative data-collection strategies suffer from similar issues. Offender interviews can cover undetected offending by known offenders, but provide no information about unknown offenders. The relatively small number of offenders who steal metal (compared, for example, to the number who shoplift) makes self-report surveys impracticable.

Given these limitations, it is likely that there will be some degree of inaccuracy in the estimates of OCG involvement produced by each method. However, the difference between the results presented here and the official estimates discussed above is large enough that it is unlikely to be solely due to inaccuracies based on data or methods. For example, the 2% of metal thefts with methods sophisticated enough to suggest the involvement of an OCG would have to be an underestimate by a factor of ten to reach the estimated proportion of offences linked to OCGs estimated by Mills et al. (2013) and by a factor of fifteen to approach the police estimates reported by House of Commons Transport Committee (2012). One limitation of this comparison is that the police estimates relate to the proportion of *crimes* related to OCGs and the results of analysis relating to F1 and F2 relate to the proportion of *offenders* linked to OCGs. If OCG-linked metal thieves were prolific metal thieves, a small proportion of such offenders might account for a higher proportion of crime. However, the results presented above show that the most prolific metal thieves are not those with links to OCGs, with

only two metal thieves linked by intelligence to OCGs having more than two sanctions for metal theft.

It therefore seems clear that the involvement of OCGs in metal theft is substantially less than is estimated by police officers working on metal-theft cases. This might seem a surprising result because police officers might be expected to know the evidence base in their field of expertise. It is therefore important to ask: why might officers over-estimate the involvement of OCGs in crime?

One answer might be that police are simply pre-disposed to look for OCGs, particularly when a new crime problem occurs. There are two potential reasons for this. Firstly, crimes committed by OCGs tend to cause more concern among both the public and professionals than comparable offences without an organised-crime link (Woodiwiss and Hobbs, 2009). Secondly, there is a strong tendency towards causal reductionism in thinking about crime: people preferentially ascribe changes in crime rates to a single cause rather than a complex interaction between multiple factors (Montgomery, 1996, p 109). The involvement of OCGs may provide a more appealing and simple explanation for a crime problem than other explanations, such as the behaviour of a large number of unconnected minor criminals being simultaneously influenced by changes in metal prices (Sidebottom et al., 2014) or fluctuating demand in the Chinese construction industry (Sidebottom et al., 2011). This is not a criticism of individual police officers – particularly those who *have* understood the influence of economic factors in metal theft – but rather a statement of how external factors can influence police decision-making.

Once practitioners or policy makers look for the involvement of OCGs in a crime type, the breadth of modern definitions of organised crime make it highly likely that they will find it. The UK government has recently adopted (in section 45 of the Serious Crime Act 2015) the definition of an OCG set out in the UNCTOC. As discussed in Section 9.2, this has four elements: (a) that the group contain three or more persons, (b) that the group exist “for a period of time”, (c) that group members commit “serious crimes” (defined in the UK as an offence carrying a *maximum* penalty of seven or more years in prison, regardless of the actual sentence imposed) and (d) that they intend to obtain material benefit (United Nations Office on Drugs and Crime, 2004, p 5). In the case of metal theft in the UK, the last two elements will always be present: the offence of theft carries a maximum sentence of seven years

imprisonment, and theft is intrinsically done for material gain. The analysis of offence methods above showed that at least 40% of metal thefts involved more than one offender, so the only remaining requirement is the need for the group to exist “for a period of time”. Since no minimum time is specified, this could be taken simply as meaning that whenever two metal thefts are committed by the same multiple offenders, they become an OCG. This does not mean, of course, that any multiple of thieves would be considered an OCG by a person on the street, but the definition is so broad that almost any such group *could* be defined as an OCG within it. The number of false-positive cases seems to be limited only by whether practitioners choose to apply the definition to its full extent in a particular case.

Once a person or organisation believes they have identified OCGs as being involved in a particular crime problem, that involvement is likely to become received wisdom as a result of the operation of two cognitive processes outlined by Tversky and Kahneman (1973). The “availability heuristic” is the human tendency to give disproportionate weight to information that easily comes to mind. In the case of metal theft, information that supports pre-existing ideas about likely causes of a problem – such as ‘metal theft is committed by OCGs’ – is likely to be repeated and therefore more easily come to mind, which in turn means it more easily comes to mind and is more likely to be repeated. The “representativeness heuristic” describes how people are more likely to believe something to be of a particular type if that thing is similar to the stereotypical description of things of that type. For example, people may believe metal theft to be committed by OCGs because it has features – such as being done for economic gain and causing substantial damage to society – that are stereotypically associated with OCGs. Confirmation bias – the tendency to give greater weight to evidence that supports existing ideas than to evidence that does not (Wason, 1960) – is also likely to push those who have chosen to look for OCGs into believing they have found them (for further discussion of how confirmation bias can influence police perceptions of crime problems, see Townsley et al., 2011, p 165). Put more simply, estimates of OCG involvement in crime problems risk “becoming self-referential, recycling the prevailing values and priorities of the political and law enforcement agencies consulted” (Edwards and Levi, 2008, p 373).

It should be emphasised that nothing in the preceding explanation should be read as a criticism of individual practitioners or policy makers who



believe OCGs are involved in metal theft. In particular, some senior BTP officers have spoken publicly of the link between metal prices and the rate of metal theft. The social and cognitive biases described here are not failures of individuals, but rather the products of how humans have evolved to think, both individually and in society. It is the inevitability of these biases influencing our thinking that makes the application of empirical study so important and the increasing interest among practitioners in “evidence-based policing” (Sherman, 1998) so welcome.

There is reason to believe that moving the focus of efforts to prevent metal theft away from the prosecution of OCGs may help practitioners and policy makers to prevent metal theft. With the exception of crime problems involving a single serial offender, incapacitating criminals is often ineffective at reducing crime because the chance of a given offence ending in imprisonment is extremely low (Barclay and Tavares, 1999). It is often more effective to employ problem-oriented policing methods (Goldstein, 1979; Eck and Spelman, 1987) such as crime scripts to identify the points in the metal-theft process at which police can have most impact. Indeed, this approach has already allowed police to identify scrap-metal dealers as key actors in metal theft and to use that understanding to reduce thefts (Morgan et al., 2015). There is some evidence to suggest that shifting to a focus on situational prevention measures of the type often used in problem-oriented policing may be effective at preventing crime even if a large proportion of it *does* involve OCGs. Edwards and Levi (2008, p 375) argued that OCG members were likely to respond to changes in the environment just as other criminals do, and that situational prevention could be an effective and inexpensive way to prevent crimes committed by OCGs. Similarly, Hancock and Laycock (2010) showed that crime scripts can be useful in identifying the points in the process of committing a crime at which interventions against OCGs are likely to be most effective.

The benefits of moving from an enforcement-based approach to a focus on prevention may extend beyond the specific problem of metal theft. There is a common perception that the involvement of OCGs in crime is often underestimated (van den Bunt, 2004; Kleemans, 2007; Dubourg and Prichard, 2007), at times taking on the appearance of a moral panic (Woodiwiss and Hobbs, 2009) in which it is asserted OCGs are a threat “the magnitude and seriousness of which cannot be overestimated” (United Nations General Assembly, 1988, p 15). By contrast, relatively little attention has been given

to the possibility that OCG involvement might be overestimated. The present results illustrate the importance of balancing potential sources of error in any estimate of OCG involvement in a crime to ensure that exclusive focus on avoiding underestimation does not make overestimation more likely.

*Note that, as a condition of access to intelligence data, the contents of this chapter were checked before publication by officers from the National Crime Agency. This was done solely to ensure that no sensitive information had been included in the text and should not be taken as implying any approval of the analysis or conclusions. No security issues were raised during this process and so no changes were made to the content.*







## DISCUSSION

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### SUMMARY

- The application of crime science to the problem of metal theft has been useful because it allows the introduction of techniques from different scientific disciplines, and because it helps to produce information of value to practitioners.
- Evidence-based policy is problematic because all evidence is provisional and may be refuted in future. Nevertheless using evidence to make policy decisions may be the least worst option available.
- Organised crime is better conceptualised as a multi-dimensional space rather than as an undifferentiated whole or as a one-dimensional spectrum as discussed in previous literature.
- An organised-crime space defined by the degree of sophistication, networking and harm involved in different types of crime allows differentiation of a wide range of different crimes committed by different types of OCG.
- Although the number of thefts of copper from the railway network appears to be decreasing in Great Britain, there is evidence that the problem of metal theft is changing and that in other countries it remains a substantial problem.

The previous chapters have each discussed an aspect of the problem of metal theft from the railway network in Great Britain. In this chapter, several issues that arose during that work and that have broader applications will be discussed.

#### 10.1 THE APPLICATION OF CRIME SCIENCE TO METAL THEFT

Section 2.2 introduced crime science as “the application of the methods of science to crime and disorder” (Laycock, 2005, p 4). It also suggested two potential consequences of adopting a crime-science approach to the study of crime. Firstly, the explicit adoption of “the methods of science” suggests that crime science will involve importing techniques from other disciplines. Secondly, being closely aligned with the needs of practitioners may make the overall research programme *appear* – from a conventional academic perspective – more piecemeal than if it were guided primarily by theory or ideology, as is common in many social sciences.

Both of these features of crime science can be seen in the work presented in this thesis. The IDEF0 modelling language used in Chapter 6 is commonly used in systems engineering, and (to the author’s knowledge) has not previously been used to represent a crime script in the literature. Similarly, the use of circular statistics to analyse temporal variation in crime (see Section 7.4) is not common, having been proposed by Brunsdon and Corcoran (2006) but little implemented<sup>1</sup>.

The empirical chapters of this thesis cover diverse questions on the topic of metal theft from railways. Potential questions were identified using the crime script developed in Chapter 6 and then selected based on the needs of practitioners engaged in the prevention or detection of railway metal theft.

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<sup>1</sup> One study that has applied circular statistics to the study of crime was that by Ashby and Bowers (2012).

There are several connections between the results of different chapters. For example, the method used to study a potential link between SMDs and metal theft in Chapter 8 relies on the finding in Chapter 7 that metal thefts are significantly clustered in particular parts of the railway network. Conversely, the findings of Chapter 8 help to explain potential causal mechanisms behind the spatial and temporal concentrations of metal theft found in Chapter 7. The analysis of the journey to crime in Section 9.7 extends the spatial analysis of metal theft in Section 7.7, while the key role of SMDs outlined in Chapter 8 informs the evidence on offence methods presented in Section 9.8.

Nevertheless, these connections arose serendipitously: the value of this work is in its practical applicability, rather than in the flow of the narrative from one topic to the next. It may be going too far to assess the value of crime-science research solely by applying the test that FitzGerald (2010, p 299) attributed to Colin Cramphorn – “what does it mean for the late turn van driver on a Friday night?” – since reducing crime requires a broader effort than police responses to emergency calls<sup>2</sup>. However, the focus of applied research must be on what impact it has on people and communities. As such, the golden thread running through this thesis is in the conceptual method used and the goal sought, rather than in the degree of linkage between the different aspects of the analysis.

#### 10.1.1 *When is evidence good enough?*

The data and methods used in each of the empirical chapters in this thesis have limitations that may influence the reliability of the results presented. Nevertheless, each chapter concludes with recommendations for practitioners on how best to apply the results to prevent or detect metal theft from railways. Section 2.2.4 discussed the issue of ethics in crime science, but one outstanding ethical issue is whether or not researchers should encourage changes in practice based on evidence that they regard to be provisional or incomplete.

The idea of evidence-based policing was originally proposed by Sherman (1998) and has progressively increased in its impact since (Sherman, 2013, p 379). It recommends “the use of research, evaluation, analysis, and sci-

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<sup>2</sup> Cramphorn, a former Chief Constable of West Yorkshire who died aged 50 in 2006, was described by *The Guardian* in its obituary as “one of the most thoughtful of Britain’s senior police officers” (Wainwright, 2006); he had previously described himself to another journalist as “the sad, tragic bastard who reads Her Majesty’s inspectorate of constabulary reports in bed” (Godson, 2005).

entific processes in law-enforcement decision making” (Lum and Koper, 2014, p 1426). This raises several questions, one of which is what should be done if available evidence is limited, provisional or contradictory. The same issue has arisen in other areas of evidence-based practice, where the “complexity of evidence, scientific controversy [and] different interpretations” (Black, 2001, p 276) have been an obstacle to changing practices based on evidence of what works.

The answer is that making decisions based on provisional evidence is inevitable, since all scientific evidence is provisional (see Section 2.3). Researchers can never know whether their results will be overturned by new data, and should always be mindful that “all models are wrong; the practical question is how wrong do they have to be to not be useful” (Box and Draper, 1987, p 74)<sup>3</sup>.

The history of science is replete with examples of scientific results overturned by later studies. Early studies on the use of “scared straight” programmes – in which teenagers visit prisons in order to deter them from committing crimes – found positive results, but later work found that such programmes often led to an increase in offending compared to control groups (Petrosino et al., 2014). A randomised controlled trial by Sherman and Berk (1984) on domestic violence found that repeat offending was reduced (over a six-month follow-up period) if police officers arrested the offenders rather than issuing warnings or taking other informal action<sup>4</sup>. This led to changes in police policies in many areas to mandate arrests of domestic-abuse suspects (Sherman and Cohn, 1989, p 123). However, a long-term follow-up study of the victims in a similar study by Sherman et al. (1991) showed that after 23 years victims whose abusers were arrested had higher homicide and all-cause mortality rates than those in the control group (Sherman and Harris, 2013, 2015). While such startling findings require further exploration, they raise the worrying possibility that police agencies in many countries could have applied the best available research evidence and caused harm by doing so.

Such examples may suggest that it is never safe to rely on the evidence of scientific research, since any evidence might be overturned in future. Nevertheless, policy decisions must still be made, even if the decision is to

<sup>3</sup> The more famous version of this idea is that “all models are wrong, but some are useful” (Box, 1979, p 202). Perhaps inevitably, it has subsequently been argued that this statement is in itself both useful and wrong (see Tarpey, 2009).

<sup>4</sup> For a vivid description of the problems of under-policing that such experiments were trying to solve, see Buel (1988, pp 213–215).



continue with current practice. Although research evidence might be refuted in future, police leaders and others must still make decisions today about what to do or not to do.

In such circumstances, the only ethical course is for policy makers to rely on the best available evidence produced by researchers using the most robust techniques for testing hypotheses and evaluating programmes. Scientific practice is imperfect and the results it produces are fallible, but it may represent the least worst method for selecting among policy choices, just as democracy represents the least worst method for choosing a government. As Auden (1945, p 123) wrote:

“The way is certainly both short and steep,  
However gradual it looks from here;  
Look if you like, but you will have to leap.”

## 10.2 AN ORGANISED-CRIME SPACE

This section will attempt to resolve an apparent contradiction between findings presented in previous chapters. Section 7.8 discussed whether the spatial and temporal patterns of metal thefts suggested that metal thieves plan their offending – at least to a certain minimum extent – and concluded that they did. The clustering of metal thefts around SMDs (as discussed in Chapter 8) also suggests at least a minimum degree of planning on the part of metal thieves. Conversely, the analysis presented in Chapter 9 demonstrated that there was very little evidence of metal thefts commonly involving OCGs, and in particular Section 9.8 found that the methods used by metal thieves rarely suggested any degree of sophistication. How can these two findings be reconciled?

One potential resolution can be found by re-visiting the problem of defining organised crime. Various definitions of OCGs were discussed in Section 9.2, which illustrated the difficulty of distinguishing the activities of such groups from other forms of crime<sup>5</sup>. Hagan (1983) argued that categorical distinction was impossible, and instead suggested that the organisation of crime be conceptualised as a continuum, from less-organised to more-organised crime. By extending this idea, it may be possible to determine why

<sup>5</sup> Note that the discussion of definitions in Chapter 9 related specifically to organised-crime *groups*, whereas the discussion here relates to organised crime more generally. However, much of the discussion (and the existing literature) can be relevant to both concepts. This is particularly true if we accept the argument of Finckenaue (2005, p 76) that “organized crime [is] that crime that is committed by criminal organizations.”

metal theft appears to involve some planning while not exhibiting many of the expected features of crime involving OCGs.

Extending the idea of an organised-crime continuum may be beneficial because of a limitation in the original concept: conceptualising the organisation of crime as a continuum restricts that variation in organisation to one dimension. In reality, this is unlikely to be a realistic model of variations in the crime organisation, as can be seen using an example. Drug supply is commonly associated with OCGs and Mills et al. (2013, p 9) claimed it is committed exclusively by OCGs. However, there are many ways in which drugs supply could vary in its relationship to organised crime: Beare and Naylor (1999) argued that “‘organized crime’ however defined, may have little relevance in the lives of the majority of criminals operating in the drug market.” For example, cannabis can be supplied by offenders who have made extensive plans to ensure the maximum yield from each plant that they grow, but can also be supplied by an individual who has simply planted some seeds in his or her garden (Hough et al., 2003, pp 7–11).

Any given degree of sophistication in drugs supply may involve a large network of offenders – such as groups smuggling large quantities of heroin using speed boats (Caulkins et al., 2009, p 83) – or a single offender working alone – such as the ecstasy dealer reported on by Massari (2006, p 10) who routinely travelled from Barcelona to Amsterdam to purchase drugs because the quality was better than was available in his own country. Any given type of drug production can also cause different levels of harm: hydroponic cultivation of cannabis can be done either for the medical needs of the grower (Dahl and Frank, 2011) or by an offender coercing vulnerable people into tending crops against their will (Kirby and Peal, 2015, p 287).

Restricting variation in the organisation of crime to a single dimension therefore has the potential to mask substantial differences between crimes committed in different ways and in different circumstances. This limitation can be overcome by thinking of the organisation of crime not as a continuum but as a multi-dimensional space in which the different dimensions represent separate features that characterise offences committed by OCGs.

There are many ways in which crimes can be distinct from one another. As a result, the number of dimensions that could be used to define an organised-crime space is potentially quite large. For example, the degree of planning involved in a crime, the methodological sophistication, the number of people involved, the value of any benefit, the type of offence, the harm caused,

the legal severity, the hierarchy of any group, the degree and nature of any corruption, the severity of environmental harm, the extent of any violence and many other dimensions could all potentially be relevant. However, a model incorporating all possible dimensions of organised crime could be so complicated as to be unmanageable.

As discussed in Section 2.3, models in crime science must be useful, and so it may be necessary to restrict the number of dimensions used. In the discussion that follows, four criteria were used to select the most appropriate dimensions with which to define an organised-crime space. In short, useful dimensions must be valid descriptors of organised crime, generalisable across potential types of crime, consistent with the UNCTOC definition of an OCG and (on a practical basis) measurable.

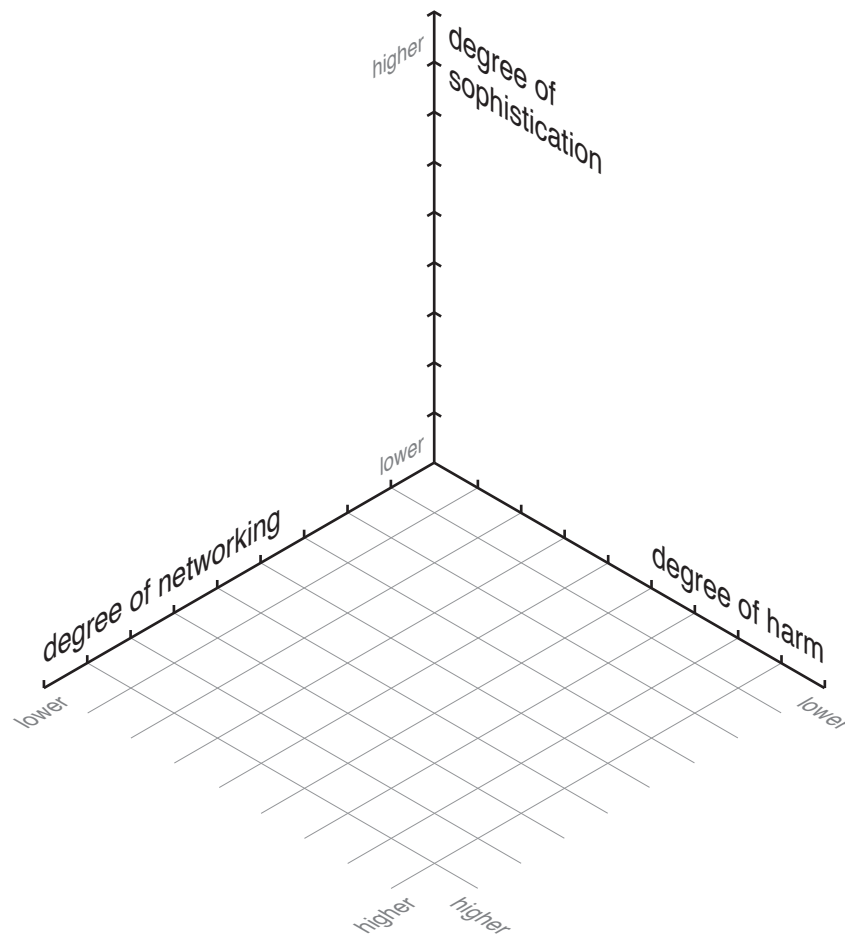
**VALID** To be of maximum use for understanding organised crime, chosen dimensions must represent widely-accepted core features of such crimes. This criterion ensures that the dimensions can be applied widely, even by analysts who might have different views on whether other, more peripheral, qualities were indicative of organised crime.

**GENERALISABLE** A useful organised-crime space must be able to incorporate a wide variety of crime types, both those that have been committed by OCGs in the past and those that may be in the future. This is necessary in order to ensure that analysts of organised crime are not artificially restricted. As such, the choice of dimensions cannot be derived from features of specific OCGs or specific types of crime committed by them, since those features may not generalise to future crimes. For example, some definitions of OCGs have used attempts by offenders to corrupt public officials as a marker of organised crime because some high-profile OCGs (such as mafia groups in the US – see Section 9.2) have previously done so. However, it is eminently possible for even quite large OCGs to operate without corrupting public officials, not least because there is very little public-sector corruption in countries such as the UK (Macaulay, 2011)<sup>6</sup>.

**CONSISTENT** The UNCTOC has been signed by all but nine countries worldwide and includes a requirement (at Article 5) to criminalise participation in an OCG as defined in the manner discussed in Section 9.2, above. As

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<sup>6</sup> Corruption of the UK criminal justice system, for example, by OCGs tends to involve incidents of individuals disclosing sensitive information to offenders (National Crime Agency, 2015, p 31).

Figure 10.1: *An organised-crime space.*

such, it appears that the United Nations (UN) definition of an OCG is likely to become widely used, at least by practitioners analysing organised crime. A definition of an organised crime space should, therefore, at the very least not be incompatible with the UNCTOC definition.

**MEASURABLE** In order to be useful in facilitating the understanding of organised crimes, dimensions of an organised-crime space must be measurable using available data, even if such measurements are imperfect.

Using these criteria, three dimensions were identified: the methodological sophistication of the offending, the harm caused by it and how networked the offending was (i.e. how many different people were involved), shown in Figure 10.1. These will be discussed in the following paragraphs, after which the application of the space will be demonstrated using examples.

### 10.2.1 *Networking*

The nature of an OCG requires that multiple offenders be involved, either directly in the crime being analysed or in a wider criminal enterprise. The UNCTOC definition of an OCG specifies that three or more persons must be involved, but some OCGs may be much larger than others. Individual Yakuza groups in Japan have been reported to have as many as 17,000 members (Hill, 2004, p 106), while some Russian OCGs may involve several thousand offenders (Varese, 2011, p 67). However, it appears that in many cases OCGs are much smaller than this: Paoli (2003, p 29) reported that mafia groups in Sicily (the archetype of an OCG – see Section 9.2) typically have between 10 and 40 members. At the extreme, a small group of burglars (a thief, a look-out and a driver) who occasionally work together would reach the threshold of three participants in what could be considered an organised crime. Clearly these groups are different from one another, but considering organised crime as a single continuum does not allow them to be distinguished clearly; this problem is solved by analysing the degree of networking separately.

Networking<sup>7</sup> can be measured using a variety of tools. In an OCG that is well understood by police, social network analysis can link the various offenders involved and determine the centrality of each offender within the network (Davis, 1981; van der Hulst, 2009; Cockbain et al., 2011). Where information is limited, secondary data such as telephone records can be used to establish how many people are involved in an OCG and identify links between offenders (Natarajan, 2006)<sup>8</sup>. Mafia-type OCGs are sometimes seen as being protected by a strong social expectation that members will not provide information to the authorities (Paoli, 2003), but in fact investigations into such groups have long involved the use of informants (Schreiber, 2001), whose information could assist in building up a picture of network structure.

### 10.2.2 *Sophistication*

The degree of sophistication involved in an offence refers primarily to the way in which the offence is committed. For example, a metal theft involving false

<sup>7</sup> The term networking is used rather than, for example ‘number of members’, to reflect the dispirate nature of many OCGs that have a shifting and loose, rather than static and hierarchical, structure (Paoli, 2002, p 67).

<sup>8</sup> This process is not without difficulty, however: is that thief calling a locksmith late at night for help in cracking a safe or because the thief has lost his car keys after an evening out?

documentation designed to deceive security guards into allowing thieves to take large quantities of metal involves greater methodological sophistication than a metal theft in which thieves collect discarded metal from the side of a railway line (see Section 9.8).

The degree of sophistication involved in an offence incorporates the amount of planning involved, since sophistication generally requires planning, either in direct preparation for that particular offence or as a result of a habit-forming process (see Section 2.5). For example, a murder committed by the victim's partner in a drunken rage may involve almost no planning, and as a result is unlikely to exhibit a high degree of methodological sophistication: the suspect may simply have beaten the victim with the nearest heavy object. Conversely, if the offender were to decide in advance to kill his partner and hire a contract killer, a much greater degree of sophistication in the offence method would be possible. That does not mean that all contract killings will be sophisticated (Macintyre et al., 2014, p 335), but simply that sophistication and planning (which can also be thought of as pre-meditation) are likely to be sufficiently correlated that (for the sake of parsimony) they need not be considered as separate variables in the organised-crime space.

The concept of sophistication is the only one of the three variables that does not have a direct analogue in the UNCTOC definition of an OCG (see Section 9.2). Nevertheless, it has been included here for two reasons. Firstly, the concept of sophistication is implicit in many discussions of organised crime. As was discussed in Section 9.3, many practitioners who stated that OCGs were involved in metal theft based their assertions at least partly upon the belief that metal thefts involve sophisticated methods. Secondly, as argued by Felson and Boba (2010, p 11), if a crime does require methodological sophistication then involving an OCG may be beneficial for an offender, but if it does *not* require it then the involvement of an OCG may become an active hinderance. For example, an offender who cannot complete a particularly challenging burglary without the help of several co-offenders would obviously benefit from involving other people. Conversely, a burglar who could adequately complete the crime alone would be foolish to tell other people of his or her plans, both because this may create unwanted competition and because one of those others may pass on information to the police (Wright and Decker, 1994, p 98). The involvement of an OCG buys the ability to be more sophisticated, but at a cost: if that benefit is not needed, why take the risk?

There is unlikely to be a single, simple and widely accepted way to measure offence sophistication. Wheeler and Rothman (1982, p 1412) attempted to measure sophistication in two ways: by coders rating offences in what they described as an “impressionistic” manner, and by looking for specific features that they designated as being indicative of sophisticated offences. However, they looked for only two such features: the use of false documents and offenders attempting to hide their offending from others. Hastings (2009), in a study of maritime hijackings, defined sophistication as a binary variable in which hijacking of ships for ransom was designed as less sophisticated and hijacking in order to sell the ship or cargo as more sophisticated. Neither of these approaches is generalisable to other forms of crime, in which the features indicative of sophistication are likely to be different. Even within the crime types under study, the selection of such a small number of features as the basis of the measurement of sophistication is likely to have failed to capture the full range of variation. For example, as Hastings (2009, p 217) acknowledged, stealing a cargo of crude oil requires substantially more resources and technical skill than stealing a similar-sized cargo of (for example) rice, but this could not be captured within his binary classification.

The approach used by Morris (2010) in studying the characteristics of identity thieves may perhaps be more generally applicable. That study used newspaper reports to identify characteristics that typically distinguished thefts from one another, such as the number of victims, the use of specialist technology and the geographic reach of the offender. From this was developed an ordinal classification of offence sophistication with four categories. Although some features of each category were highly specific to identity theft (such as the number of bank accounts opened in each victim’s name), the process by which these features were identified could be replicated for other types of crime.

### 10.2.3 *Harm*

The harm caused by OCGs is the primary reason why they are considered a worthwhile topic for the attention of academics and practitioners. OCGs are often described as causing substantial harm to society (US Department of Justice, 2008; Europol, 2013; HM Government, 2013), but it is likely that the harm caused will vary between OCGs and between types of organised crime. For example, the sale of counterfeit medicines by OCGs has led directly to the

deaths of people consuming the drugs (Patrignani et al., 2012, p 29), a type of harm that is unlikely with the sale of (for example) counterfeit clothing<sup>9</sup>. Similarly, the trafficking of people for sexual exploitation could be said to cause greater harm than the smuggling of used cars to avoid import duties (Centre for the Study of Democracy, 2002, pp 22–23). By not considering harm separately, a single organised-crime continuum conflates crimes that cause substantially different impacts on society.

The UNCTOC definition of an OCG incorporates harm through the requirement that the group commits “one or more serious crimes”, defined as offences “punishable by a maximum deprivation of liberty of at least four years” or more (United Nations Office on Drugs and Crime, 2004, p 5). The incorporation of this definition into the law of England and Wales by Section 45 of the Serious Crime Act 2015 differs slightly from the UN definition, in setting the threshold for “serious” crime as being potential imprisonment for seven years, rather than four. However, both definitions take a binary approach to harm: either an offence is serious enough to be considered as a type of organised crime or it is not. Such an approach, however, fails to distinguish the enormous variations in harm caused by different OCG activities: a binary definition of seriousness treats, for example, an OCG involved in shoplifting as being the same as one involved in trafficking people for sexual exploitation.

The harm caused by OCGs will vary in character as well as in degree. Savona and Vettori (2009, p 385) distinguished between tangible (financial losses), intangible (physical injuries and psychological harm) and systemic (harm through social destabilisation) costs of organised crime. The costs associated with OCG activities will vary according to the type of crime involved: corruption of public officials may involve minimal tangible and intangible costs but very substantial systemic costs (Williams, 1994, pp 109–110), while installing banking malware on home computers (Donohue, 2013) can cause large tangible costs but very few systemic ones. A further issue is that a crime may have the potential to cause substantial harm but (through a quirk of circumstance) does not do so – should the actual harm be measured or the harm that the offenders were willing to cause, either intentionally or recklessly?

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<sup>9</sup> This does not mean that there is no harm associated with counterfeiting of clothing: purchasers may suffer a financial loss if counterfeit goods are of poor quality, counterfeit goods are often produced in factories with poor working conditions, and the proceeds of selling counterfeits may facilitate other harmful activities (Europol, n.d.).



Measuring the harm (whether tangible, intangible or systemic) caused by an OCG may be problematic because of the difficulty of obtaining reliable data: an assessment by Johnston et al. (2010) for the Canadian government concluded that there was insufficient reliable information available to even attempt such measurement. Another problem with measuring the societal cost of OCGs is that some provide social and community services in areas where formal authority is absent (Venkatesh, 2008, p 41), introducing the notion of societal benefits associated with OCGs that may off-set some of the costs.

Despite these difficulties, attempts have been made to measure the tangible harm associated with OCGs. Levi et al. (2013) estimated the costs associated with different types of organised crime in the EU, although they recognised that the data were incomplete and that this meant their estimates would have a wide margin of error. They concluded that the “minimum identifiable direct economic costs” were (for example) €97 billion for fraud against individuals, €30 billion for human trafficking, €11 billion for cigarette smuggling and €4 billion for theft of motor vehicles (Levi et al., 2013, p 10). However, the authors could not produce estimates for several types of organised crime (including drugs smuggling) because of the lack of available data. Beare and Naylor (1999) criticised attempts to put a financial value on the cost of organised crime, noting that the available data are often generated using unreliable methods and that “regardless of the desire for these numbers or the care with which they are gathered/calculated – the numbers themselves must in most cases mean very little”.

An alternative approach is to use the severity with which criminal laws treat different types of crime as a proxy measure for the harm caused by that crime. For example, the difference in the severity of punishment handed down for a murder and that available to punish an incident of graffiti can be used as a proxy for the different levels of harm associated with the two offences. Sherman (2013) and Ratcliffe (2014) proposed indices of crime harm based on the severity of punishment recommended in national sentencing guidelines, while Ignatans and Pease (2015) suggested a similar measure based on survey-derived victim perceptions of offence seriousness. Using sentencing guidelines avoids the problem (discussed in Section 9.2) that would be encountered if maximum possible sentences were used, as they are in the UNCTOC definition of an OCG, in that some crimes have maximum

possible sentences vastly in excess of those typically imposed<sup>10</sup>. Sherman et al. (2016) used a crime harm index (CHI) based on sentencing guidelines to show that (for example) rape accounted for less than 1% of recorded crime in England and Wales but 15% of crime harm. Given that sentencing guidelines exist for a wide range of offences, it is likely that a similar CHI could be applied to the analysis of organised crime.

#### 10.2.4 *Other dimensions*

The multi-faceted nature of crime makes it inevitable that there will be debate about which dimensions should be used to define an organised-crime space. This section will attempt to explain why some obvious candidate dimensions were not chosen in place of those that were.

Some variables were not chosen because they are incorporated within the chosen dimensions. For example, the extent of corruption or violence associated with an OCG were not included as dimensions because they are incorporated within the dimension of harm, while the existence of a group hierarchy was considered as part of the networking dimension.

Finckenauer (2005) argued that OCGs are characterised by four qualities: sophistication, structure (defined in a similar way to the concept of networking described above), self-identification and "authority of reputation". The latter two concepts have not been used as dimensions here because they do not meet all of the four specified criteria. Some OCGs may display self-identification by "the use of colors, special clothing, language, tattoos, initiation rites, etc." (Finckenauer, 2005, p 75) – this appears to be particularly true of Chinese Triad groups, for example (Obokata, 2010, p 18). However, there does not appear to be any evidence that this is a defining feature of all (or even most) OCGs. For example, the author was not able to find any published accounts of such ritual behaviour among groups trafficking drugs or arranging the sexual exploitation of children in the UK. As Schloenhardt (1999, p 203) argued, much research in this area "is highly anecdotal and often focuses on myths of initiation rituals of 'secret societies' rather than

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<sup>10</sup> For example, in England and Wales the maximum penalty for possession of cannabis (a class B controlled drug) where there is no evidence that the person intended to supply the cannabis to another is five years in prison or an unlimited fine (Misuse of Drugs Act 1971, Schedule 4). However, the sentencing guidelines for drug possession recommend a penalty of a fine equivalent to one week's wages for a first-time offender, and stipulate that sentences of longer than six months in prison may only be imposed in exceptional circumstances (Sentencing Council, 2012, p 30). As such, the penalty even in serious cases is unlikely to be more than one tenth of the maximum penalty available by law.

providing an analytical approach”, suggesting that using ritualised self-identification as a defining dimension of an organised-crime space would fail to satisfy the generalisability criterion set out above. The same appears to be true of the final characteristic outlined by Finckenauer (2005, p 75): that “the organization’s reputation [is] sufficient to instill fear and to intimidate others”. While some OCGs undoubtedly use such intimidation, it may well be that (for example) groups of derivatives traders committing large-scale banking fraud (such as in the Libor scandal – see Ashton and Christophers, 2015) would have neither the need nor the capacity to instill fear in others.

#### 10.2.5 *An organised-crime space in practice*

The organised-crime space described here is primarily useful as a tool for analysing and comparing OCGs. For example, it could be used to prioritise the targeting of particular groups. This could be done based either on a single dimension or combination of all three. In either case, such analysis would not be possible either with a binary definition of organised crime, or with a unidimensional organised-crime continuum.

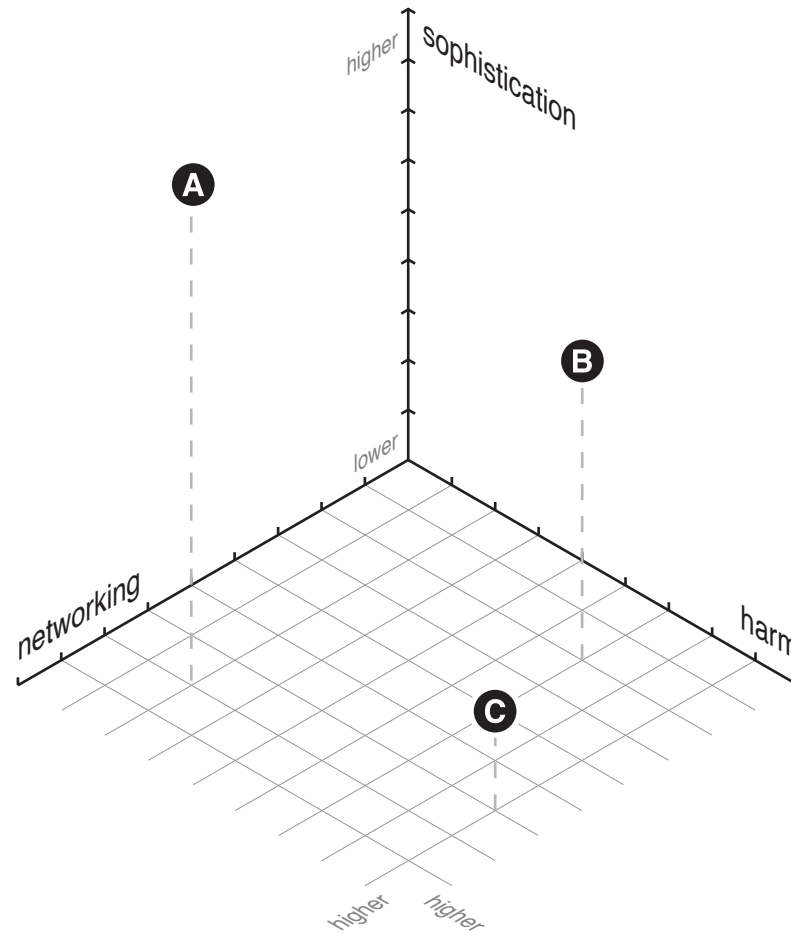
Figure 10.3a shows how an organised-crime space could be used to differentiate three (fictional) groups, all of them satisfying the criteria set out in the UNCTOC OCG definition. OCG A has a large number of members and uses sophisticated methods but causes relatively little harm. Such a group might be involved in stealing high-value cars, disguising their identity (‘ringing’) and then exporting them for sale abroad (Clarke and Brown, 2003). OCG B, by contrast, is somewhat less sophisticated and involves a smaller network but causes greater harm. This might be a small people-smuggling group that clandestinely transports people across an international border hidden in freight lorries (Antonopoulos and Winterdyk, 2006, p 453)<sup>11</sup>. Finally, OCG C is the least sophisticated of the three but involves a large network and causes substantial harm. This might be, for example, a group that uses the internet (but not strong encryption or other sophisticated methods) to exchange images of child sexual abuse (Eichenwald, 2006).

Some OCGs may score highly on all three dimensions. For example, a large South American cartel distributing cocaine to Europe (OCG D in Figure 10.3b) may involve a large network using sophisticated methods to cause substantial

<sup>11</sup> For a discussion of the distinction between people smuggling and human trafficking, see Iselin and Adams (2003).

Figure 10.2: *Examples of groups in an organised-crime space.*

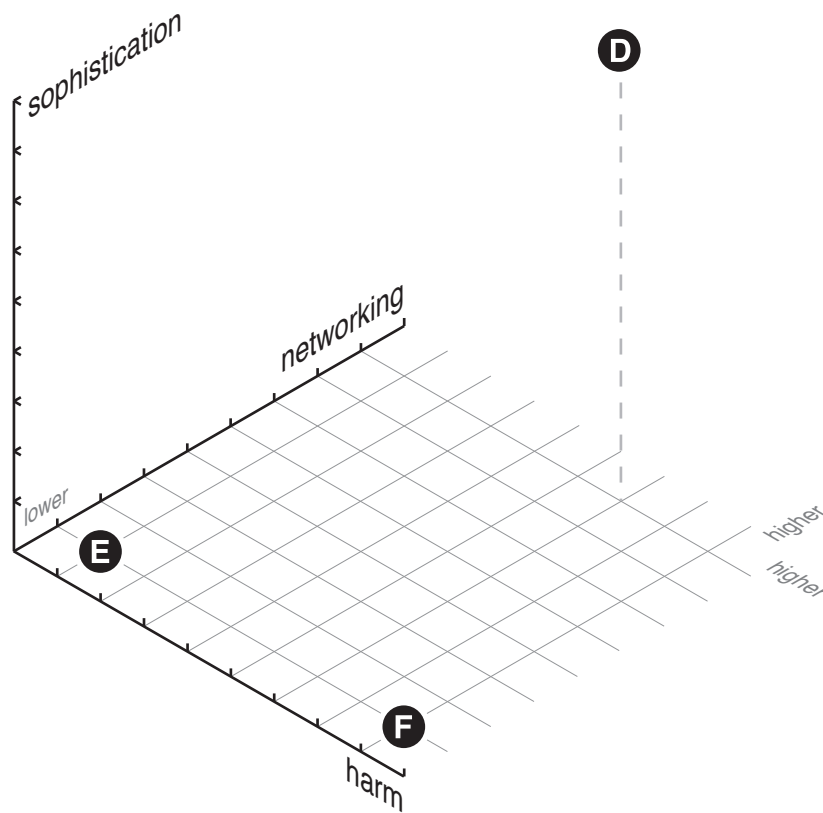
(a) A fictional car-ringing gang (A), people-smuggling group (B) and child-pornography network (C) within an organised-crime space.



harm. Conversely, some groups (such as OCG E) will be relatively small, unsophisticated and cause little harm. In between those two extremes, the organised-crime space model allows for more-precise description of what differentiates OCGs from one another. For example, the smuggling of nuclear material from the former Soviet Union (OCG F in Figure 10.3b) has the potential to cause enormous harm (Lee, 2006), and as such has been the cause of considerable concern among governments (e.g. Mirsky, 1996; Orttung and Shelley, 2005). However, groups involved in nuclear smuggling have been found to “typically comprise loose assortments of former nuclear workers, small metals traders, opportunistic businessmen and petty smugglers” (Lee, 1997, p 112) rather than large networks of offenders. Available evidence also

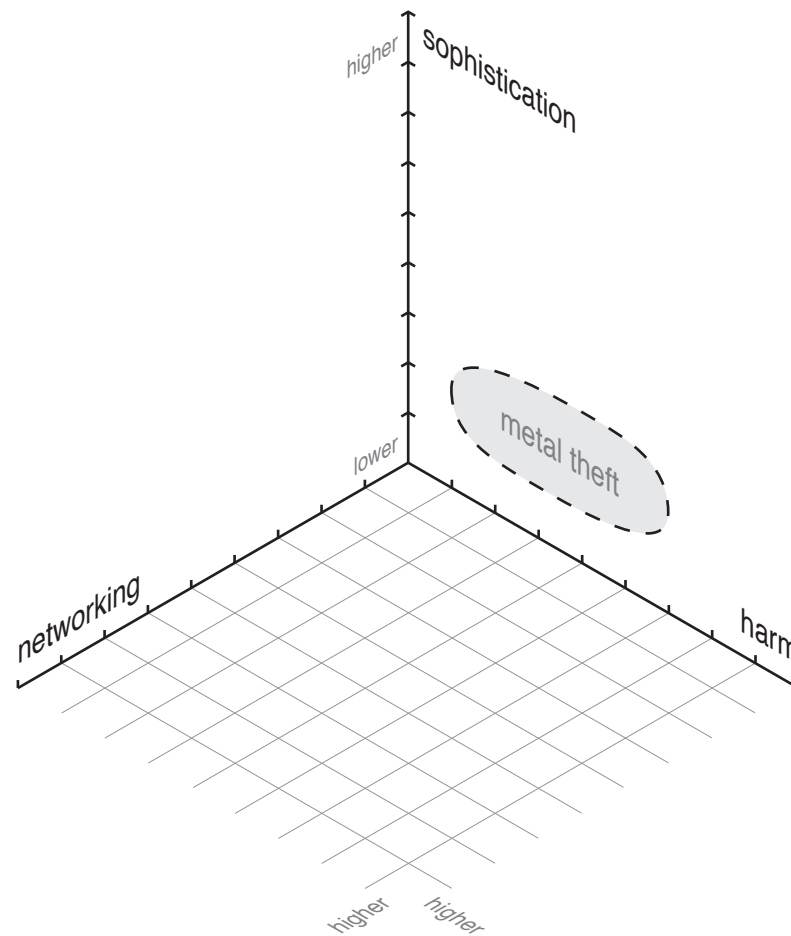
(b) A cocaine cartel (D), minor OCG (E) and nuclear-smuggling group (F) within an organised-crime space.

Note: diagram rotated from that in Figure 10.3a for ease of viewing.



suggests a lack of sophistication among such groups: Zaitseva (2007, 827) reported two cases of smugglers hiding highly enriched nuclear material in their homes without any type of radiation shielding. Conceptualising organised crime as a unidimensional continuum would make analysis of such groups difficult, since there would be a tension between their shocking lack of sophistication (on one hand) and the potentially catastrophic harm that could result from their activities (on the other). Using an organised-crime space allows them to be clearly distinguished.

It is in this way that an organised-crime space provides a potential resolution to the apparent contradiction described above that metal thefts appear to often involve at least a small degree of planning (as found in Section 7.8) but at the same time typically do not involve OCGs (as described in Chapter 9). Figure 10.4 shows metal theft from the railway network in Great Britain within an organised-crime space. In general, the degree of networking is low: the research presented in this thesis found no evidence of large OCGs being

Figure 10.4: *Metal theft within an organised-crime space.*

involved in metal theft. In most cases the degree of sophistication is also moderately low, although there is some variation: a small number of offences appear to involve moderate sophistication by virtue of (for example) some offenders being willing to travel longer distances, to use forged documents or to plan their offending in advance. The degree of harm associated with metal theft is the most variable. Some offences have the potential to cause substantial harm through disruption to infrastructure networks, but a large number of offences cause little if any harm. Meanwhile even the most harmful metal thefts will not be as harmful as, for example, the child-pornography network shown in Figure 10.3a or the nuclear-smuggling group shown in Figure 10.3b.

The use of an organised-crime space in the case of metal theft illustrates why assessing crime problems using a multi-dimensional approach is likely to be more useful than making a binary judgement about whether a problem relates to organised crime or not. There is no bright line between crimes

that are organised and those that are not, and nor is there a single variable that defines more-organised crimes from less-organised ones. The organised-crime space recognises this, and in doing so provides a more sophisticated tool for the analysis of OCGs. In particular, it allows the different groups shown in Figure 10.2 to be distinguished from one another, and from other criminal groups, without the limitations of a binary or one-dimensional definition of organised crime. Differentiation is important because how practitioners tackle particular groups may differ depending on their nature. For example, countering a cocaine cartel with a high degree of networking and sophistication may require lengthy surveillance and detailed analysis of financial records, while these methods may be of only limited use in tackling a nuclear-smuggling group with low sophistication and only a small network.

### 10.3 IS METAL THEFT A SOLVED PROBLEM?

In the years immediately before the research reported in this thesis began in mid 2012, metal theft had appeared as a new crime problem of substantial concern to policy makers and the public alike. The charity Crimestoppers (2015), for example, described the “misery and disruption metal thieves can cause for local communities” and gave examples of thefts leaving homes without power, forcing businesses to close and causing widespread disruption when traffic lights stop working (for further discussion of the harm caused by metal theft, see Chapter 3).

By the time this research concluded in mid 2015, the situation had changed substantially. As shown in Figure 3.2, there were fewer than 50 metal thefts per month from the railway network in 2015, down from more than 200 per month in the spring of 2011. In a speech given in January 2015, the UK Home Secretary used metal theft as an example of successful crime reduction activity by her department (May, 2015), a claim repeated in the government crime-prevention strategy (Home Office, 2016, p 7). As a result, the Home Office has discontinued funding for the National Metal Theft Task Force (Verrinder, 2014), a multi-agency hub for information sharing that had previously been lauded for its effectiveness (Home Office, 2014).

It seems clear that the magnitude of the problem of metal theft from the railway network in Great Britain has reduced, in terms of the number of recorded offences, in the past five years. Figure 3.1 shows that the global

wholesale price of copper has been decreasing since it peaked at \$8,470 per tonne in 2012 (World Bank, 2016), which may have reduced the incentives to steal copper (Sidebottom et al., 2011, 2014). Morgan et al. (2015) found that the progressive implementation of intensive police monitoring of SMDs in different regions of England was associated with a decrease in the number of recorded metal thefts both from the railway and electricity-distribution networks. However, only limited research has been conducted to date: replication and extension of this work would be required in order to fully understand why the frequency of metal theft from these networks has decreased.

The metal most-frequently stolen from the railway network is copper (Sidebottom et al., 2014, p 690), and so the recent decrease in metal theft from railways in Great Britain can largely be seen as a decrease in the theft of copper. The picture in relation to the theft of other metals, and the theft of copper from other sources, is more mixed. Although the latest data from the Office for National Statistics (2015b) show that the number of metal thefts recorded by police across England and Wales has decreased, these statistics have only been collected for three years.

The National Crime Agency (2015, p 27) has noted that while theft of copper was decreasing, theft of some precious metals such as palladium (which is used in catalytic converters on motor vehicles) has increased. The same report noted that this was partly related to decreased mining of such metals in parts of Africa affected by the 2013–2016 Ebola epidemic, although it is likely that increasing world-wide car production is also increasing demand (Hagelüken, 2012, p 196).

Although reliable data are extremely limited, outside the UK it appears that there has been less of a reduction in the frequency of metal theft, if any. According to the Association of European Rail Infrastructure Managers (EIM): “despite ... legislative measures taken at Member State level, despite EIM members having implemented a wide range of countermeasures, and also despite joint actions within EIM ... the problem largely persists” (EIM, 2015, p 1). The International Union of Railways (UIC) referred to metal theft as “an intolerable burden for railway companies” (Colliard, 2015, p 22). In May 2015, a consortium of 11 associations representing transport and energy providers, police forces and recycling groups published a call for the EU to take co-ordinated action against metal theft (European Coalition Against



Metal Theft, 2015). They emphasised that metal theft in Europe continues to cause

“huge economic losses for businesses and society ... creates potential risks for the safety of companies’ staff and citizens, and has negative impacts on the quality of services and security of supply ... and as such represents a threat to the internal security and economies of EU Member States” (European Coalition Against Metal Theft, 2015, p 1).

They went on to describe the problems associated with different European countries having different laws and procedures governing metal theft and the regulation of SMDs. For example, the ability to buy scrap metal for cash in Germany may have limited the effectiveness of cashless transaction laws in France, since thieves can transport stolen metal across the border to sell.

The available data do not allow a direct comparison of the frequency of metal theft in different countries. However, discussions with practitioners and government officials in the UK and other European countries suggest that there is a perception in Britain that metal theft is a problem that has largely been solved, while in (for example) France, Belgium and Germany it is seen as a current threat. One reason for this may be that evading national crime-prevention activity by transporting stolen metal across borders may be more difficult in the UK than in countries with extensive land borders. Although the study of metal theft outside the UK is beyond the scope of this thesis, existing European research on this crime type has relied heavily on data on thefts from the railway network in Great Britain and work to study other sectors and other countries may be valuable.

This chapter discussed the value of a crime-science approach to understanding crime problems. This approach is valuable because it allows analysts to incorporate methods and insights from other disciplines, and because it encourages them to produce results that are relevant to practitioners. These benefits are particularly important because evidence in the study of crime is at the same time provisional and vital to allow policy makers to take evidence-based decisions.

This chapter also discussed definitions of organised crime, concluding that a multi-dimensional organised-crime space would be a more-useful concept than existing definitions. A space defined by variations in the degree of

sophistication, networking and harm was shown to allow differentiation of many types of OCG.

The final chapter of this thesis will summarise the findings of the previous chapters and make suggestions for future research.





## CONCLUSION

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### 11.1 THE PRESENT RESEARCH

The purpose of this thesis is to assist the understanding and prevention of metal theft from the UK railway network using crime science. Three such opportunities were identified in Chapter 6 using a crime script.

Chapter 7 used the routine-activities approach to identify spatial and temporal patterns in metal theft that might be useful for understanding and prevention. Thefts were found to be highly concentrated in a few hotspots, and it was shown that those hotspots were themselves clustered. Thefts were also shown to happen more often at particular times of day. These concentrations were similar to those found for other types of crime (see Section 7.1).

Some of the other findings outlined in this chapter, however, suggested that there are differences between the concentration of metal theft and concentrations of other types of crime that have previously been studied. Firstly, it appears that railway metal thefts cluster in the areas surrounding cities but not in cities themselves, in contrast to many other types of crime that occur most often in urban areas (see Section 7.8). Secondly, railway metal thefts appear to exhibit less seasonality than many other types of acquisitive crimes, although a short-term decrease in offending around Christmas was noted (see Section 7.4). Thirdly, it appears that the risk of repeat offending at a previously targeted location persists for longer in relation to railway metal theft than for any other type of crime previously studied (see Section 7.6).

These findings are valuable for two reasons. Firstly, they provide information that is useful for practitioners in attempting to combat metal theft



from railways. For example, the finding that the phenomenon of repeat victimisation is present in the distribution of metal theft, but that it persists for an unusually long period, is useful for police commanders deciding how to deploy resources after a theft occurs. Secondly, the results are useful for academics studying crime because they illustrate both the importance of crime-specific analysis (see Section 2.4.3) and the value of testing existing findings on new and emerging types of crime (see Section 7.2). These benefits are inter-related: in the absence of the work presented here, police commanders deciding for how long patrols of an area should be continued after a metal theft may have withdrawn patrols after a week on the basis that repeat-victimisation risk typically decays quickly. However, such a decision would have had to be made on the basis of studies of other types of acquisitive crime, while (as shown in Section 7.6) repeat-victimisation risk in railway metal theft appears to persist for several months.

Chapter 8 explored the relationship between SMDs and metal theft from railways. This analysis took into account potential confounding variables such as the density of population and industry in an area, the accessibility of the area by main roads, and the relative availability of metal to steal from railways (see Section 8.6.1). The method of analysis was also more appropriate to the data than previous analyses of the same question, and took into account potential spatial autocorrelation in the dependent variable (see Section 8.7). The result of this work showed that there was a significant positive association between the number of SMDs in an area and the number of railway metal thefts (see Section 8.8).

This analysis was subject to the limitations outlined in Section 8.9, in particular the inability to confirm a causal link using non-experimental methods. Despite these limitations, the work extends the study of risky facilities previously introduced in Section 2.6.3 by partially refuting the contention of Wilcox and Eck (2011) that it is the additional footfall associated with such facilities that makes them appear risky. The results are also relevant to practitioners, in that they provide support for a crime-prevention focus on SMDs based on the MRA. Discussions with practitioners (particularly outside the UK, where in many countries action against metal theft has only recently begun) suggests that they find robust empirical analysis useful because any link between SMDs and metal theft is controversial as it can be used to support additional public regulation of private businesses. Empirical study of other types of crime have in the past led public authorities to take

action to encourage businesses to take action to prevent crimes facilitated by their operation. One example of this is the car-theft index described by Laycock (2004).

Chapter 9 demonstrated that, contrary to the perceptions of many – including some practitioners – there is very little evidence of the involvement of OCGs in metal theft from railways. Since gathering information on OCGs is made difficult by the secretive nature of such organisations, and because of the many contested definitions of organised crime (see Section 9.2), the analysis used multiple methods to identify features of the problem of metal theft that might indicate the involvement of OCGs. From this analysis, it appears that very few metal thieves are linked to OCGs by previous convictions (see Section 9.5) or intelligence information (see Section 9.6). It also appears that metal thieves typically offend close to home in a manner that is common for volume-crime offenders but not for OCG members (see Section 9.7). The analysis in this chapter also demonstrated that very few metal thefts are committed using sophisticated methods or equipment that might make the the involvement of an OCG either necessary or beneficial (see Section 9.8).

These results are important for practitioners because they indicate that an approach to tackling metal theft focused on investigating OCGs would be likely to be unsuccessful, and that approaches successfully used to combat other types of volume crime may be more effective. Section 9.9 discussed a three-stage potential mechanism that may explain why people might over-estimate the involvement of OCGs in particular types of crime. This may have implications beyond the study of metal theft if it helps to explain other police practices that run contrary to available evidence. The results presented in Chapter 9 may also be useful to academics and practitioners because they illustrate how the hypothesis-testing approach to crime analysis (see Section 9.3) can be applied to crime problems.

Chapter 10 introduced the idea of a multi-dimensional organised-crime space. Although only limited application of the concept was possible within the scope of this thesis, it may allow better analysis of, and in particular differentiation between, different OCGs in future. The choice of harm, networking and sophistication as variables (see Section 10.2) with which to define an organised-crime space are not definitive and have not been empirically tested in comparison to other possible variables, including those discussed in Section 10.2.4. However, the discussion above suggests that they are capable of providing the discrimination necessary to distinguish OCGs

and to make the concept valuable. Further work in this area may shed light on these outstanding questions.

As discussed in Section 10.3, the nature of metal theft from the railway network in Great Britain (and potentially elsewhere) is changing, with fewer offences than at the peak seen in early 2011. This raises the question of whether the work presented in this thesis remains valuable to practitioners, given that the crime dataset used ended in 2012 and the offender data in 2013 (see Chapter 5).

The emphasis that crime science places on producing evidence that is useful for the prevention and detection of crime (see Section 2.2) means that evidence must be produced in a timely manner. While late evidence may be better than no evidence – since it can be applied to similar or recurrent problems in future – evidence for decision making is less useful if it appears after the relevant decisions have been made in its absence.

To ensure that the current work had the maximum impact, findings were disseminated incrementally as different parts of the analysis concluded. This was done by publishing the results in academic journals, by ensuring that all publications were open access, and by presenting the results at conferences and meetings attended by both policy makers and practitioners (see page 11).

Incremental publication of results of PhD research appears to be becoming more common, but is by no means universal. Given the importance for crime prevention of policy makers and practitioners receiving timely, robust scientific evidence in order to make the best possible decisions (Sherman, 2013), the present author believes that there is a moral imperative for crime-science researchers to publish and actively disseminate research as soon as possible (but no sooner, to preserve the quality of the analysis).

## 11.2 IMPLICATIONS FOR PRACTITIONERS AND POLICY MAKERS

The results presented in this thesis have several implications for practitioners and policy makers attempting to prevent or detect metal theft. These are summarised here for ease of reference.

The crime script described in Chapter 6 was developed in order to identify research questions that were both testable and potentially useful. However, the script also highlighted how the IDEF0 modelling framework can be used to show the tools and situational characteristics that facilitate each script unit. For example, Figure 6.3 shows that, in order to steal metal, a



potential thief must first identify metal that is vulnerable to theft, and that doing this depends on both the visibility of metal and the thief's knowledge of different metal types. This, in turn, suggests that if metal can be made less visible or disguised so as to frustrate the thief's ability to identify it, it will be less likely that this unit of the script will be completed. In this way the IDEF0 framework, with its focus on identifying tools and mechanisms (see Figure 2.1), could be useful to crime analysts in identifying potential crime-prevention measures.

Chapter 7 discussed spatial and temporal patterns of metal theft that may be useful to practitioners. Thefts were found to be concentrated in a small number of areas, which were themselves clustered (see Section 7.7). This result was expected because almost all types of crime are spatially clustered, but it illustrates the importance of police activity being geographically focused where it is needed most. The importance of targeted policing was reinforced by the findings that metal theft is clustered in time (particularly overnight – see Section 7.5) and that the spatio-temporal patterns of thefts vary in different parts of the country (see Figure 7.7).

Although the clustering of metal theft could have been predicted based on research on other types of crime, the locations of the clusters were more surprising. Many types of crime cluster in inner cities, but railway metal theft appears to cluster on the edges of urban areas (See Sections 7.7 and 7.8). This finding is likely to be useful to the police in targeting their activity, but also demonstrates the importance of studying specific types of crime rather than making deployment decisions based on analysis of 'crime' as an undifferentiated whole.

The temporal distribution of metal thefts may also be useful for practitioners. While it was expected, based on previous research of other crime types, that there was likely to be an increased risk of further thefts after an initial theft at a location, it was not expected that this risk appears to last for much longer (up to six months) than for other types of crime (see Section 7.6). This finding may influence police decisions on deploying resources, particularly if the longer risk period justifies the installation of (for example) covert closed-circuit television (CCTV) or motion sensors to detect return visits by thieves.

Chapter 8 demonstrated that metal thefts are clustered in space around the locations of SMDs (see Section 8.8). This is relevant to policy makers because it validates their application of the MRA (see Section 8.2) to the

problem of metal theft by targeted regulation of SMDs to make it more difficult or more risky for thieves to sell stolen metal at scrap yards (see Section 8.1). However, it is important for policy-makers to be mindful that it is likely that only a minority of SMDs are actively involved in metal theft (see Section 8.4.1) and so a delicate balance must be struck between preventing the harm caused by metal theft while minimising harm caused by any damage to the metal-recycling industry (see Section 8.9).

In finding support for the MRA, Chapter 8 again illustrates the importance of studying different types of crime rather than relying on findings from one crime type to make decisions about other offences. In this case, previous studies have found very limited support for the MRA in relation to residential burglary (see Section 8.2), but it appears to have merit in relation to railway metal theft.

Chapter 9 is relevant to practitioners both in relation to the specific case of metal theft and because it illustrates a wider point. In relation to metal theft, it appears that the involvement of OCGs is substantially less than practitioners have previously believed (see Sections 9.5 to 9.8). Although a very small proportion of metal thieves have links to OCGs, it appears that in almost all cases metal thefts require very little sophistication and are unlikely to require the resources of an OCG (see Section 9.8). This suggests that efforts to combat metal theft should focus on measures that are appropriate to high-volume crimes rather than on applying the extensive investigative resources that are necessary to combat OCGs (see Section 9.9). For example, measures to increase the difficulty of accessing otherwise-vulnerable metal may be more effective than using surveillance or telephone monitoring of previous offenders.

The more-general point illustrated by Chapter 9 is that it is important to test the judgements of even the most-expert practitioners in a particular type of crime. The experts who estimated relatively high levels of involvement of OCGs in metal theft no-doubt did so in good faith, but (for reasons outlined in Section 9.9) those estimates nevertheless appear to have been inaccurate. Human judgement is valuable but flawed, and should be supplemented by evidence whenever empirical information is, or can be made, available.

The final implication of the results reported in Chapter 9 is that applying a binary definition of organised crime is unlikely to be useful in practice, except in the most-extreme cases. As was discussed in more detail in Section 10.2, considering the organisation of crime as a phenomenon that varies

in several different ways is more likely to produce useful information. For example, thinking of organised crime in this way would allow practitioners to distinguish between a small group planning to commit a very-high harm offence such as nuclear smuggling from a very-large group that is involved in lower-harm offences such as vehicle theft.

### 11.3 FUTURE RESEACH DIRECTIONS

Metal theft is a relatively new crime problem and many of the research gaps identified in Chapters 3 and 4 remain. There are many potential avenues of future research, but given the importance of producing actionable knowledge quickly enough for it to be of use to practitioners (see Section 10.1.1) it will be important to prioritise the research that is most likely to be useful.

#### 11.3.1 *Understanding the metal-theft process*

The crime script discussed in Chapter 6 is based on the best-available knowledge of how metal theft from railway networks occurs. However, that knowledge is undoubtedly incomplete and could be improved with further research. Two studies in particular may be useful.

Firstly, very little is known about how offenders select particular targets, both in terms of deciding on a location at which to offend (function A2 in Figure 6.2) and on deciding which of the different available metal installations (see Figure 3.3) to attack once at the location (function B3 in Figure 6.3). Our knowledge of these processes could be improved by interviews with offenders, but (as discussed in Section 5.3.1) these are difficult with metal thieves. An alternative approach would be to compare the metals stolen to those that are available for theft, to identify those targets (either types of metal or types of installation) that are disproportionately favoured by offenders. Such research would require a source of reliable data on which metals are stolen, and similar data on the types of metal and types of installation used on the railway. The latter could be obtained by an audit of the targets available at a representative sample of railway sites. A related avenue of exploration would be the involvement of railway employees and contractors in metal theft (see Section 6.3.5), since they are likely to have specialist knowledge to inform their choice of targets.

Secondly, almost nothing is known about how some metal thieves seek to avoid detection by exporting stolen metal directly to other countries (functions D1 and D2 in Figure 6.5) beyond anecdotal evidence from police officers that such efforts have occurred. Research to better understand such direct-export thefts would be particularly useful because it would help determine whether the increased regulation of SMDs has led to method displacement by thieves who are now unable to fence stolen metal through SMDs. This research would also provide an insight into the wider issues relating to how the increasing volume of global trade and the long-distance transportation of otherwise-mundane goods can provide new crime opportunities. While the transnational dimensions of crimes such as wildlife smuggling are well known, it would be useful to have a better understanding of the potential role that globalised transportation networks can have on crimes that might otherwise appear to be local problems to be tackled exclusively by local police.

As well as these unexplored questions, the present research has identified new questions that could be usefully answered with better data. As discussed in Section 5.2.2, the presently available data on metal theft often include only imprecise crime locations – research with better data (perhaps derived from GPS recordings) may allow exploration of micro-scale spatial patterns of metal theft. This would be particularly useful because it would open up the potential for the analysis of how the very-local environment influences when and where thefts happen. Better data on the disruption caused by individual incidents could also be used in a harm-weighted analysis of spatial and temporal variations of metal theft, which would allow discussion of whether hotspots of crime harm are different from concentrations based solely on crime counts.

### 11.3.2 *Preventing metal theft*

At present, little is known about the effectiveness of measures to prevent metal theft beyond the application of the MRA to the regulation of SMDs discussed in Chapter 8. Practitioners (and particularly infrastructure owners) have implemented several other techniques in order to prevent metal theft, but (to the author's knowledge) none have been evaluated.

For example, railway companies have attempted to increase the effort associated with metal theft by burying signalling cables underground. Since

this intervention also makes it more difficult to maintain the cables, it would be important for any evaluation to compare the costs of burying cables against the benefits. Other owners of vulnerable metal have attempted to increase the risks associated with theft by treating the metal with synthetic identifying solutions such as SmartWater or Selecta DNA, apparently without evaluation.

One potential barrier to producing robust evidence of what works to reduce metal theft is that almost all interventions have been implemented only very recently. As such, it is difficult to know anything about their medium- or long-term effectiveness. It is possible that measures that are effective in the short term will lose their effectiveness over time, and so even if initial evaluations are positive follow-up studies will be necessary.

### 11.3.3 *Testing existing findings in other contexts*

Existing published research on metal theft has been heavily dependent on data from the US and (especially) the UK. There is reason to think that the situation in other countries may be different, for example if the involvement of OCGs in metal theft was different in countries in which such groups are more entrenched or have a larger influence on society. The effect of national metal-theft laws on the movement of metal across international borders also remains unexplored. This is likely to be particularly important in small jurisdictions, in which it may be easy for thieves to circumvent laws by transporting stolen goods across borders (particularly land borders inside customs unions, which typically lack routine inspections of transported goods).

Due to the availability of data, existing metal-theft research has focused on thefts from infrastructure networks (particularly railways). It may be that features of heritage metal theft (for example) are different, and research could usefully establish this. This may be particularly important because lead, which is commonly stolen from heritage sites, has different properties to the copper often stolen from infrastructure networks. For example, lead can be smelted at low temperatures without specialist tools, meaning thieves can more-easily disguise its origin. Conversely, lead is less valuable per tonne than copper, meaning more of it must be stolen (and transported) to realise the same benefit.



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CRIME-SCRIPT QUALITY-ASSURANCE CHECKLIST

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The following table details the compliance of the crime script presented in Chapter 6 with the quality-assurance checklist proposed by Borrión (2013) and shown in Table 2.1. For further discussion, see Section 6.4.

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Typology	As described in Section 6.2, the script relates to actions observed through recorded offences methods or discussions with practitioners. As shown in Figure 6.2, the script models the activities of offenders.
Traceability	The relationship between elements in the script is shown explicitly by the arrows in the figures in Section 6.3.
Transparency	The method used to develop the script is explained in Section 6.2.
Consistency	Consistency of method, terminology and visual representation is ensured by the use of IDEF0 modelling.
Context	The context in which the script operates is shown by the controls and mechanisms shown in the script diagrams.
Completeness	While all crime scripts are necessarily incomplete, the use of IDEF0 modelling requires the inclusion of the main factors that link each unit in the model.
Parsimony	The script re-uses theoretical terms defined in Chapter 2 to ensure parsimony.
Precision	As discussed in Section 6.2, the script seeks to describe information at a level of abstraction that is useful to decision makers
Uncertainty	One of the limitations of IDEF0 modelling is that it does not allow the modeller to demonstrate the certainty associated with each part of the model (see Section 6.4). However, in the present script uncertainties are described in the narrative description accompanying each unit in the model.
Usability	As described in Section 2.5.1, the IDEF0 modelling language was chosen so as to present information in a way intelligible to decision makers.
Ambiguity	As far as practicable, the terms used in the script are those defined and discussed in Chapter 2.
Accuracy	The script is based on analysis of the best available information about metal theft, although this information is necessarily limited by the difficulty in obtaining information about a process that the participants wish to keep secret (see Section 6.4).

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## DATA SOURCES

The data used in this thesis were obtained from several sources. All data were used with permission of the copyright owner. As discussed in the text, the main suppliers of data were British Transport Police and the National Crime Agency. The following sources of data were subsidiary to these main sources.

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